POWER

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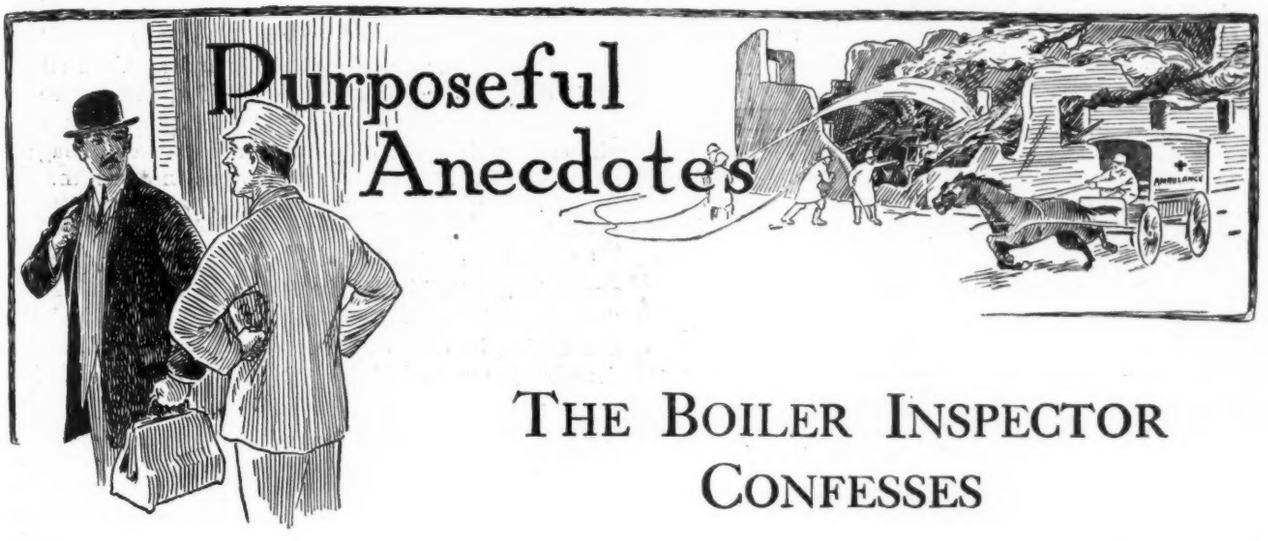


THE BOILER INSPECTOR CONFESSES

The old boiler inspector looked at me over his glasses with all the seriousness of a strong man approaching the confessional. He WAS going to confess.

• • • •

"NO, SIR, I never made half-way inspections. But as a young man I passed conditions I knew were not real bad, but bad enough to warrant giving attention. If a boiler were shut down at such a time, it meant delay. The engineer or the superintendent complained and everybody got a grouch. If I felt that the boiler would go until my next visit, which might be in six months, I'd pass it to make everybody happy. There was nothing seriously wrong in doing this, for if I doubted that the boiler would last until my next visit, it had to be made right, kick or no kick.

"This went on for years. In one plant, the B—— works, I'd thus favored the engineer a few times. The next time I was in the town I was anxious to get over to this plant for I knew the boilers needed inspection. About four o'clock that day and just as I was washing up after I'd finished the A—— company's boilers, Wilkens, the engineer, came rushing into the washroom and asked:

"'Did you hear about it?'"

"'About what?'"

"'Why, two boilers at the B—— works just exploded. They say 14 women were killed.'"

"I didn't reply; I couldn't. My knees shook; I grew hot and cold—I was sick! When I arrived at the works, fire lines had been established and there was a heavy police guard which wouldn't let me through. I looked into an ambulance and saw three forms covered with a sheet.

"Walking around to the next block I got into the yard through an alley. In the débris I hunted for the remains of the boilers, one of which I knew had a thin crown sheet—the sheet I'd inspected and passed. As I stooped to pick up a steam gage, my hand nearly touched an arm, the hand of which bore a wedding ring. I drew back trembling until the dampness at my feet caused me to look down. My shoes were soaked in blood! Oh! but I was sick. I felt worse than a murderer—I had murdered fourteen!

"Nearly crazed, I ran to the street and boarded a car for the hotel. I tried to hide behind a newspaper, but it rustled loudly in my shaking hands. I turned, pretending to look out the window, but the reflection of my face in the glass frightened me more than the staring eyes across the aisle.

"Investigation showed that the fireman had opened the blowoff valve, and before closing it rushed away on a signal from the engineer. Before he returned the explosion had happened. This knowledge relieved my mind, but I had learned my lesson.

"Now I take no chances; I strike the sheets or blowoff pipes solidly. If they are badly corroded, I must know it. Yes, they say I'm too exacting. Some complain to our head office, but I'm going to inspect rightly or I'm not going to inspect at all.

"A good engineer never complains about a thorough inspection. Some poor ones do, but we must protect them against their own shortsightedness."

Salmon River Power Plant

By Warren O. Rogers

SYNOPSIS—The principal features of this hydro-electric development are: A concrete dam 50 ft. high and 675 ft. long, which creates a storage reservoir having a capacity of 2,600,000,000 cu.ft.; two miles of conduit for conveying the water from the dam to the power plant, consisting of a section of reinforced-concrete-lined tunnel, a section of 11-ft. and 12-ft. diameter wood-stave pipe and a section of 11½-ft. diameter steel pipe; a gigantic surge tank 50 ft. in diameter and 105 ft. high, mounted on a structural tower 100 ft. high; four 8-ft. diameter steel penstocks equipped with valves of a new design; the power house, containing four 10,000-hp. horizontal turbines equipped with heavy flywheels, each driving a 6600-kv.-a. generator, together with the transforming, switching and control apparatus; and, finally, a transmission line 42 miles in length, operated at 60,000 volts.

The completion of the new Salmon River hydro-electric plant (Fig. 1), of the Salmon River Power Co., located near Altmar, N. Y., and about forty-five miles

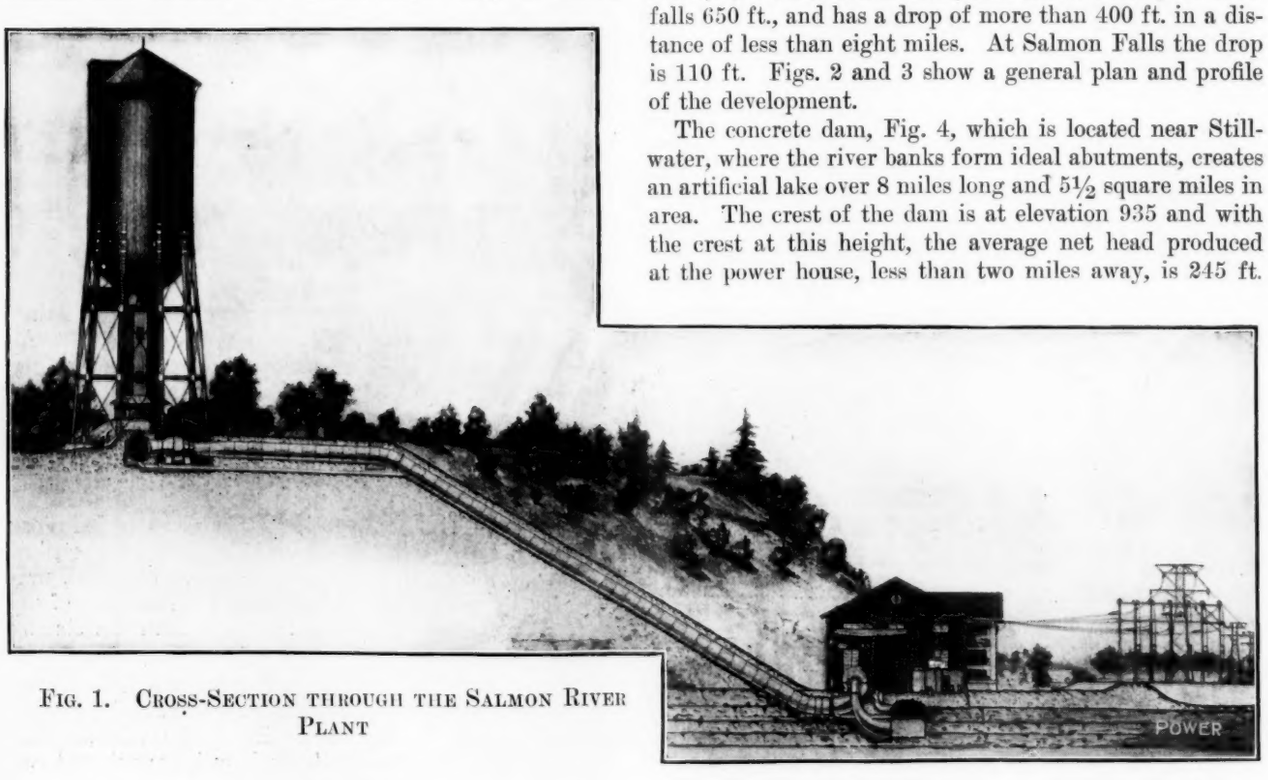


Fig. 1. Cross-Section through the Salmon River Plant

northeast of Syracuse, has attracted considerable attention to this source of water power, which, with the exception of Niagara Falls, is the greatest in the State of New York.

The power from the Salmon River will join that coming from Niagara, as the Salmon River plant has been designed to operate in parallel with the Ontario Power Co., of Niagara Falls. The latter, located in Canada, generates power for transmission over lines owned and controlled by separate and independent companies. All lines in Canada are owned by the Ontario Transmission Co., Ltd., a subsidiary corporation. In the United States the power coming from the Ontario Power Co. is distributed by the Niagara, Lockport & Ontario Power Co., over about 816 miles of transmission lines through the western and central sections of New York State. The latter company has leased the entire property of the Salmon River Power Co. in perpetuity and acquired all its capital stock, thus securing for itself a new source of power at the eastern end of its transmission lines, supplementing that which it now receives from Niagara and from its own steam plants at Lyons and Auburn.

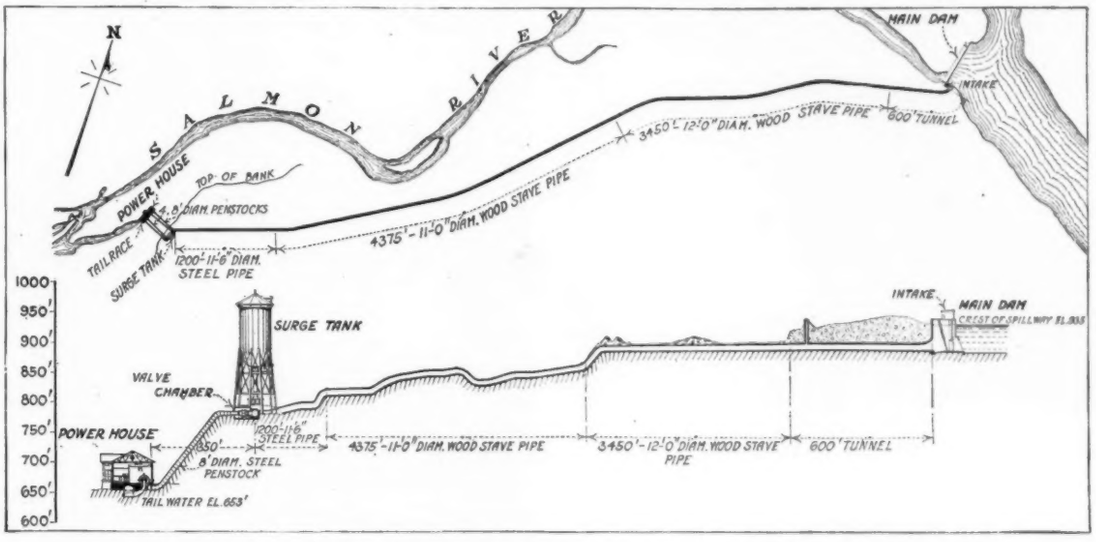
Water Supply

The Salmon River, which is 44 miles long, has its source in the foothills of the Adirondack Mountains and flows through the north-central part of New York State, discharging into the eastern end of Lake Ontario. The river drains a watershed, the tributary area of which is 190 square miles and in which there is an average annual rainfall of about sixty inches. In the 17 miles between Stillwater, where the dam is built, and Lake Ontario, the river falls 650 ft., and has a drop of more than 400 ft. in a distance of less than eight miles. At Salmon Falls the drop is 110 ft. Figs. 2 and 3 show a general plan and profile of the development.

The concrete dam, Fig. 4, which is located near Stillwater, where the river banks form ideal abutments, creates an artificial lake over 8 miles long and 5½ square miles in area. The crest of the dam is at elevation 935 and with the crest at this height, the average net head produced at the power house, less than two miles away, is 245 ft. The dam, constructed of concrete, is 675 ft. long and has a maximum height of 50 ft., with an average thickness of 51 ft. The cubical contents are 30,000 yd.

Water is conveyed from the reservoir first through the intake where the screens and head gates are located, into a 600-ft. section of reinforced-concrete-lined tunnel drilled through the rock and having an internal diameter of 12 ft. The lining of the tunnel is in no instance less than

one foot in thickness and is reinforced with circumferential rods closely spaced. From the tunnel the water passes into a 7825-ft. length of wood-stave pipe, 3450 ft. having an internal diameter of 12 ft. and the remainder 11 ft. Fig. 5 shows the manner in which the wood-stave pipe is held circumferentially with 7/8- and 1-in. steel bands. Each band is in three sections, all united by malleable-iron shoes. Where the soil is soft the pipe is supported by timber cradles. At all other points it is laid on the ground and banked with earth. To equalize external pressure when emptying the pipe and to permit air to escape when filling, relief valves are provided at intervals. The lower end of the wood-stave pipe is connected through a specially constructed joint, packed with oakum and lead wool, to a 1200-ft. section of 11½-ft. steel pipe, which conveys the water to the crest of the hill behind the power house. At this point, Fig. 6, there are a number of novel and original features.



FIGS. 2 AND 3. GENERAL PLAN AND PROFILE OF THE SALMON RIVER DEVELOPMENT

SURGE TANK

First, there is a distributor, Fig. 7, which is a 12-ft. steel pipe of 5/8-in. steel plate, 210 ft. long and joined at one end to the pipe line in a huge concrete anchor block, the other end being closed by a bulkhead. The bottom of the distributor is 160 ft. below the crest of the dam. From the center of the distributor a 12-ft. riser branches off to the surge tank, Fig. 8, the largest of its type yet constructed. The surge tank consists of a cylindrical shell 50 ft. in diameter and 80 ft. high, surmounting a bowl bottom of 25 ft. in depth, making a total height of 105 ft. and having a capacity of 1,400,000 gal. of water. It is supported on 10 massive steel columns spaced as shown in Fig. 7, which elevate the bottom of the tank 80 ft. above the ground level. The total height of the complete surge-tank structure is 205 ft.

The thickness of the bowl bottom plates is 7/8 in. and the longitudinal seams are triple-riveted butt-strap joints; the horizontal seams are quadruple-riveted lap joints. The first, or bottom course of the shell, is of 1-in. plate with triple-riveted butt joints. The thinnest plate in the tank is ½ in. thick. The portion of the riser inside the tank is stiffened every 4 ft. by 4x4x½-in. angles to take care of any temporary differences in the elevation of water inside the riser and in the tank proper.

The 12-ft. riser from the distributor connects with the surge tank by means of a special expansion joint. In order that the accelerating or retarding head required to produce the new velocity in the pipe line and demanded by a change in load on the plant may be more quickly established, the 12-ft. riser is reduced to a diameter of 10 ft. inside the tank. This interior riser is flared at the top to a diameter of 15 ft. and terminates 5 ft. below the top of the tank proper. In the annular opening formed between the 12-ft. riser and the 10-ft. riser at the bottom of the bowl, ports have been provided, so that water moving toward the tank flows partly into the main tank and partly into the interior riser, and conversely, water flowing downward through the 12-ft. riser flows partly from the 10-ft. riser and partly from the main tank through the ports.

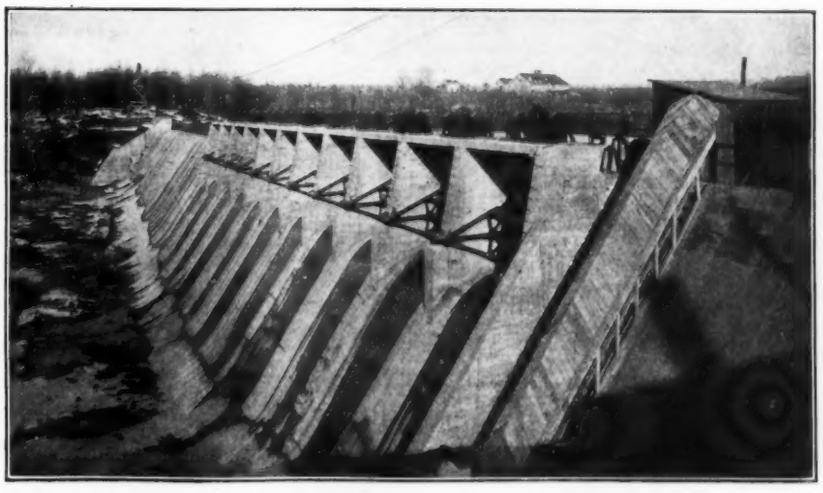


FIG. 4. SALMON RIVER CONCRETE DAM

The surge tank acts as a hydraulic regulating device

for the plant and to protect the long pipe line from shock. When the plant is in operation and a sudden demand for more power occurs, requiring more water, this

FIG. 5. TWELVE-FOOT WOOD-STAVE PENSTOCK

is supplied largely from the surge tank, while the velocity in the pipe line is increasing to the required degree. When the power load is suddenly diminished or thrown off the plant, the surplus water surges into the tank, producing a rapid rise in the interior riser and a slower rise in the main tank. The head produced in the riser checks the velocity of flow in the pipe line and limits the pressure.

If, under very severe and unusual conditions of load change, the water in the riser should reach the top, it would spill over into the main tank and be retained.

The ports at the bottom of the tank are carefully designed so as to introduce just the right amount of resistance to the flow of water to or from the tank proper in order that any surges produced in the hydraulic system by sudden demands for and rejections of power may be effectively damped before serious oscillations in the water column are set up. Also, by the use of this "differential" principle both the maximum head and the required storage capacity in the tank are reduced, making

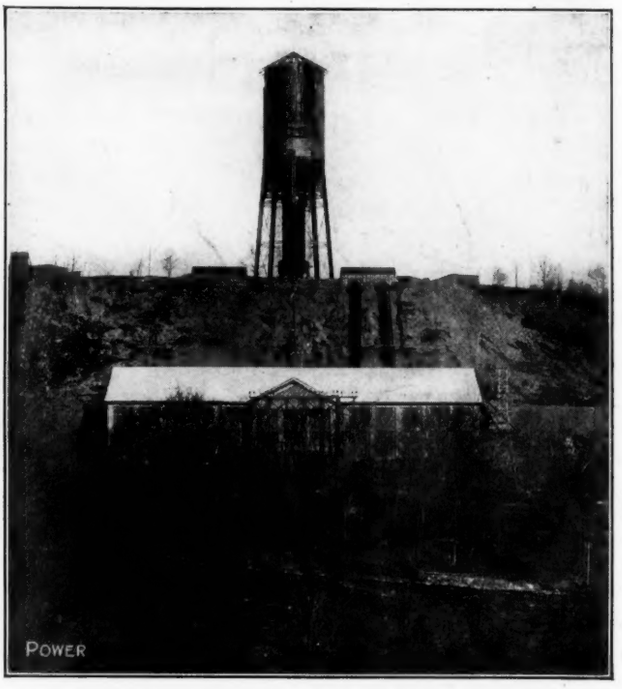


FIG. 6. SURGE TANK ON HILL BACK OF THE POWER PLANT

possible lower construction costs and better hydraulic regulation.

Another interesting feature in connection with the surge tank is the provision which has been made to prevent freezing. The tank is housed in with a framed wooden structure, which provides a series of air spaces

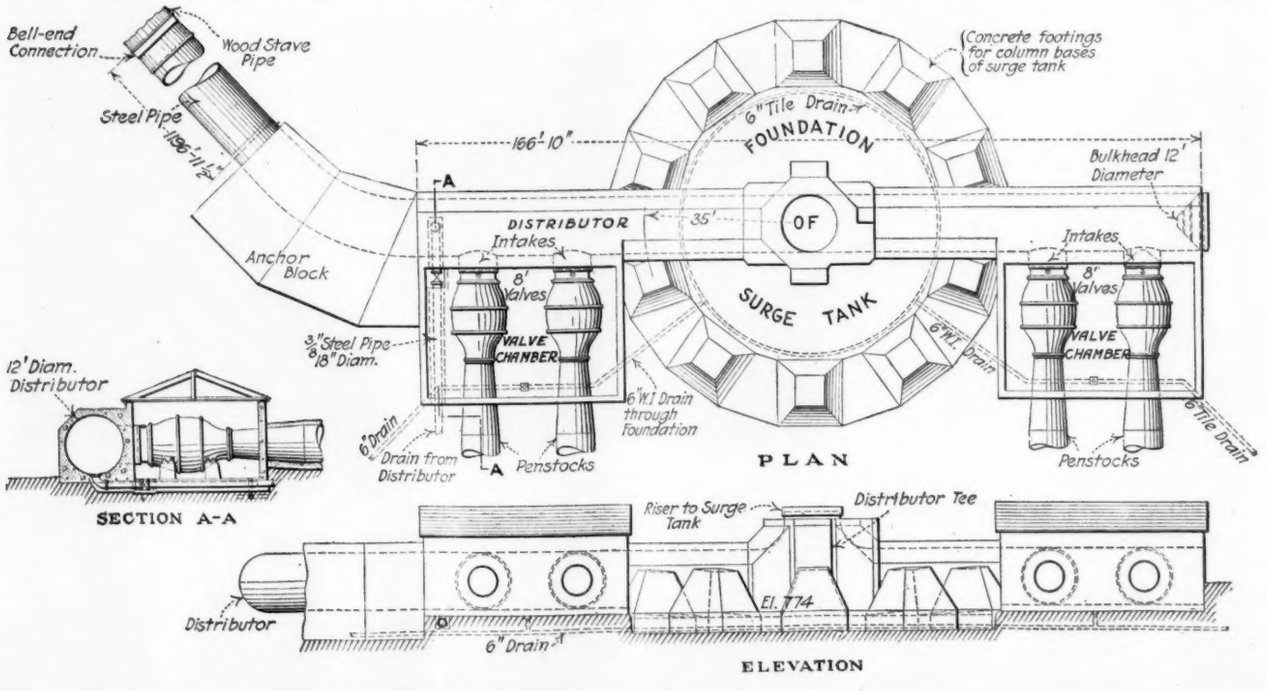


FIG. 7. PLAN AND ELEVATION OF THE 12-FT. DISTRIBUTOR

through which warm air is blown whenever necessary by fans located at the base of the tank.

Hydraulic Valves and Penstocks

Four 8-ft. penstocks are connected to the distributor through hydraulic valves of a new design. The normal head under which these valves operate is 154 ft. An exterior view of one of the valves is shown in Fig. 9; a sectional view in Fig. 10. The valve consists of a casing which supports an internal stationary shell *A*, headed against the flow of water, as indicated by the arrow. A hollow movable plunger *B* carries a bronze ring *C*, which seats against a ring *D*. The movement of the plunger is controlled by a four-way valve and suitable piping. The pipe *E* is connected to the penstock on the intake side of the valve, the pipe *F* is piped into the space behind the plunger, *G* into the space between the plunger and the shell, and *H* discharges to the air.

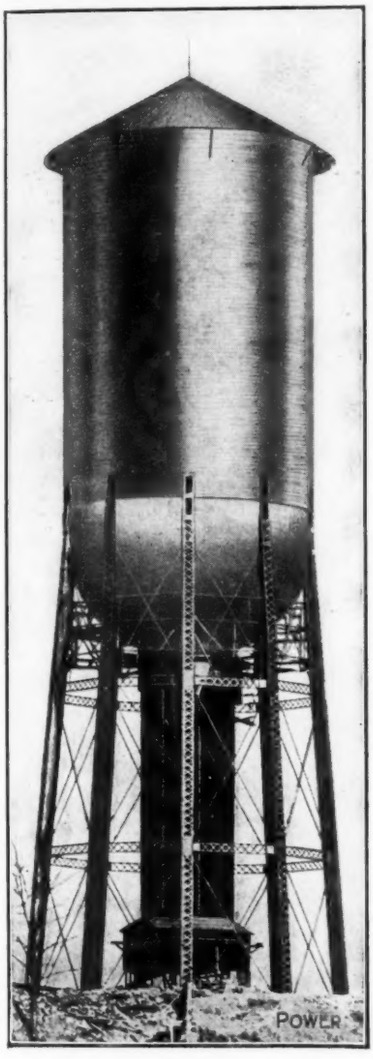


Fig. 8. Near View of the Surge Tank

To close the valve the pressure in the pipe *E* is put in communication with the pipe *F*, and pipe *G* with *H* by means of the four-way valve, thus putting pressure behind the plunger and gradually closing the valve. When opening the valve the pipe *E* is put in communication with *G*, and *F* with the pipe *H*. The plunger can be stopped at any point between its full open and closed position, its exact position at any time being designated on the indicator shown in Fig. 9. The four-way valve is either hand or motor driven and can be electrically controlled from the main switchboard in the power house. In order that the switchboard operator may know that the valve is operating properly, a pilot lamp, controlled by suitable contacts on the valve indicator, is installed on the control switchboard in the power house.

From the valve chambers four 8-ft. steel penstocks, which are anchored above and below in heavy concrete blocks and laid in trenches which are back-filled, run to the power house. Two are seen in Fig. 6, as they had not been covered with earth at the time the photograph was taken. The thickness of the steel plate of which the penstocks are constructed varies from ½ in. on the upper horizontal end to ⅞ in. at the lower end, where they enter the power house.

Power House

The power house is constructed of reinforced-concrete columns connected with heavy concrete beams. The panels around the large window areas are filled on the inside with sand-lime brick and with red brick on the outside. The building is rectangular, with a projecting feeder bay. In the feeder bay and along one side of the main generator room is a gallery about 12 ft. above the main floor. A 40-ton electric crane, with main and auxiliary drive of 250-volt direct-current motors, spans the generator room, which is 38 ft. wide.

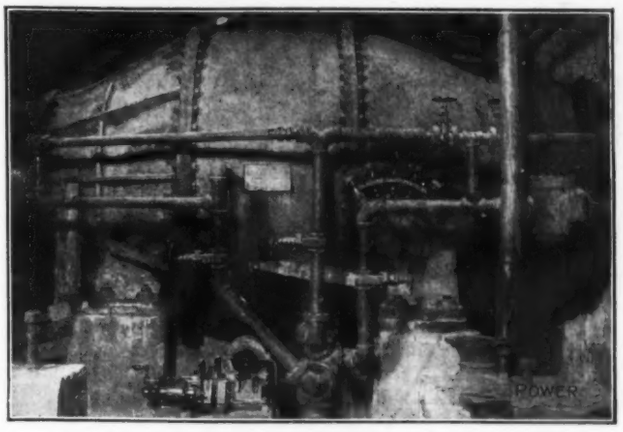


Fig. 9. An 8-Ft. Johnson Penstock Valve

All intake pipes, draft tubes and discharge tunnels are under the building, embedded in or formed of concrete which rests on solid rock; the arrangement of this is shown in the plan and elevation views, Figs. 11 and 15.

Main Units

There are four turbines of 10,000-hp. normal rating of the Francis horizontal, single-spiral, double-discharge type, which are provided with outside-balanced wicket gates operated by hydraulic governors.

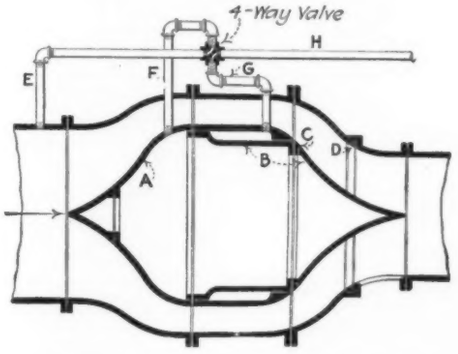


Fig. 10. Sectional View of the Penstock Valve

The turbines have guaranteed efficiencies of 82 per cent. at full load, 85 at three-quarter load, 80 at half load and 70 at quarter load. On the turbine shafts are mounted heavy flywheels to assist in governing and to facilitate the operation of the electrical equipment of the plant in parallel with other plants on the transmission system. Relief

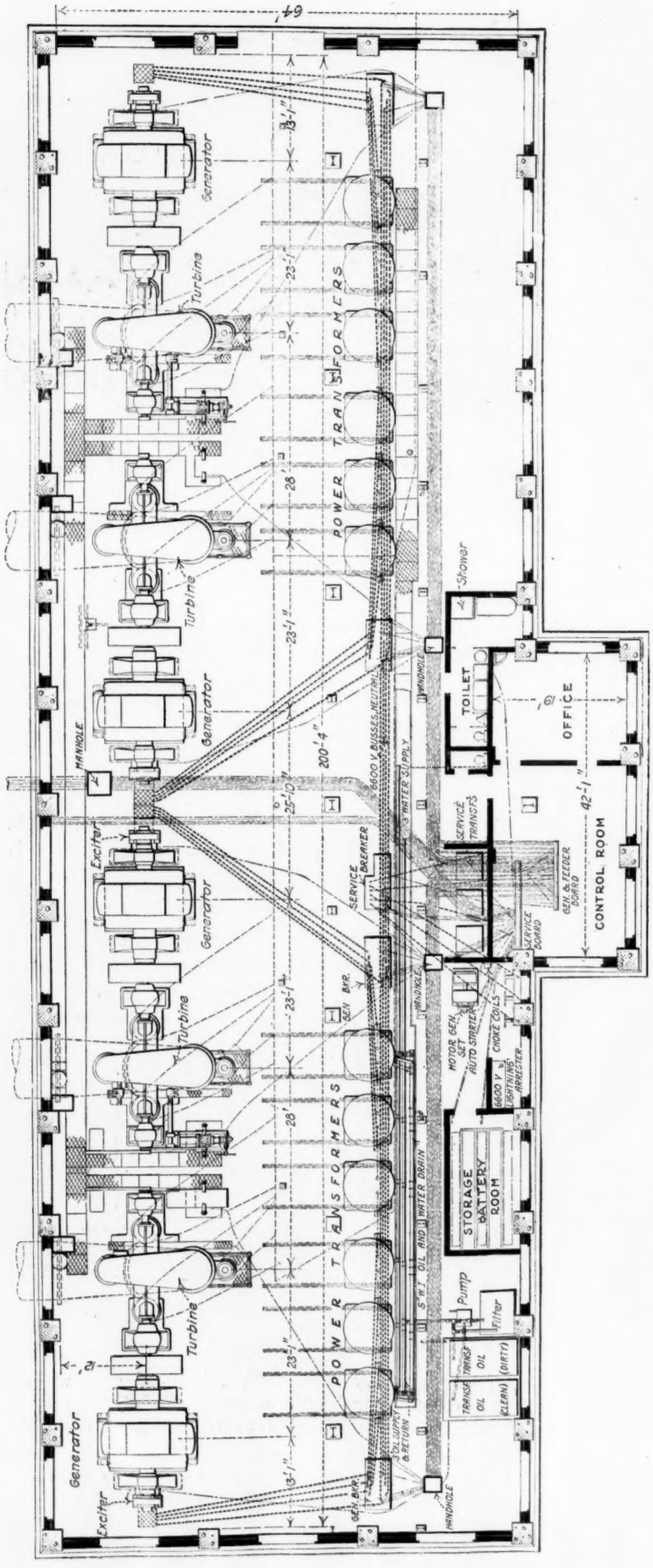


FIG. 11. PLAN OF THE POWER PLANT SHOWING THE ARRANGEMENT OF THE MAIN UNITS AND ACCESSORIES

valves on the turbines, operated by the governors, prevent excessive pressure rises upon sudden closure of the turbine gates. Nos. 1 and 2 units are shown in Fig. 14.

The hydraulic governors, Fig. 12, are adjusted to permit of not more than 15 per cent. increase in speed above normal on the sudden removal of the full load carried by the generator, 6 per cent. for half load, 3 per cent. for quarter load and 1.5 per cent. for one-tenth load.

The turbines discharge into a tailrace through short concrete draft tubes, entering at an obtuse angle to prevent eddies. The tailrace is under the power house, which is built over the bed of a branch of the river. The exit of the tailrace from the building is closed by a curtain wall which prevents the ingress of cold air.

The four generators directly coupled to the turbine shafts are 6600-kv.-a. capacity, 6600-volt, 25-cycle, three-phase units. The exciter of each machine is mounted on an extension of the shaft, Fig. 14, and is adapted to voltage and power-factor control by a voltage regulator. The pole faces of each generator are provided with damping grids. The generators are of the semi-inclosed type, and the cooling air is discharged through a large opening in the top of the casings. They are designed to operate either as generators or synchronous condensers, in order that they may be used both for generating electrical energy and for power-factor correction on the long transmission line from Niagara. Each is designed to carry 20 per cent. overload and is also capable of operating at full current output up to 7500 volts. The limits of voltage regulation allowed at normal kv.-a. load were for 100, 90 and 80 per cent. power factor, 12, 25 and 28 per cent., respectively.

STATION ELECTRICAL EQUIPMENT

The electrical equipment for each generator further consists of three 2200-kv.-a. single-phase, 25-cycle, oil-cooled transformers, Fig. 13, with a normal ratio of 6600 to 34,650 volts, the high tension in star giving 60,000 volts on the line; a 6600-volt, 1200-amp., triple-pole, single-throw circuit-breaker, automatic for reverse power, and the necessary connecting cables and auxiliaries. The duplicate high-tension busbars are hung from the roof, over the gallery, upon which are located the high-tension line and the transformer circuit-breakers and line choke

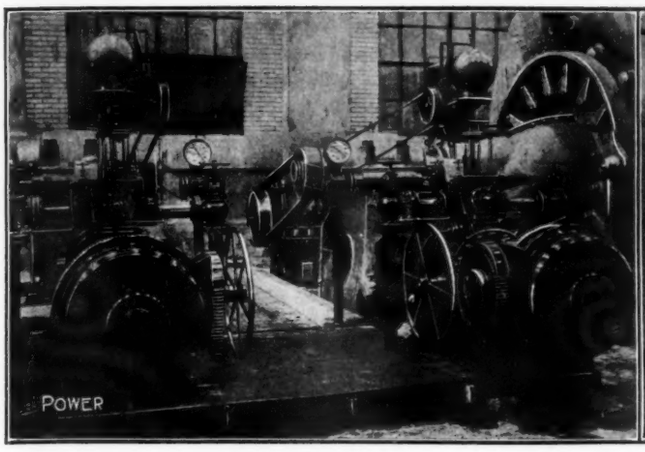


FIG. 12. HYDRAULIC GOVERNORS

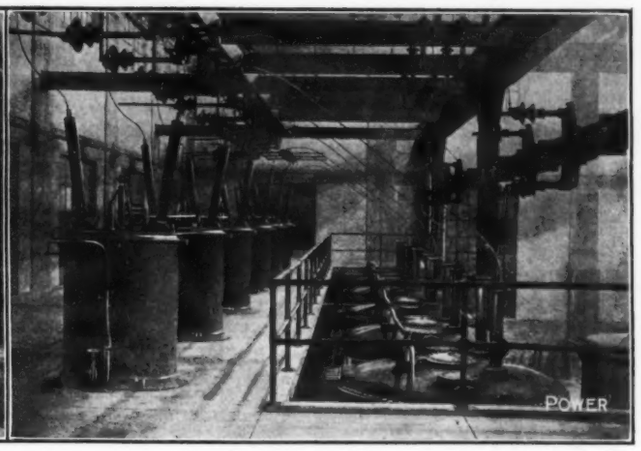


FIG. 13. OIL-COOLED TRANSFORMERS

PRINCIPAL EQUIPMENT OF SALMON RIVER POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Turbines	Horizontal single spiral	10,000-hp	Main units	375 r.p.m., 245-ft. head	Wellman-Seaver-Morgan Co.
4	Generators	Alternating current	7920-kv.-a.max.	Main units	375 r.p.m., 6600 volts, 25 cycles, three-phase	Westinghouse Electric & Mfg. Co.
4	Generators	Direct current	150-kw	Exciter units	375 r.p.m., 125-245 volts	Westinghouse Electric & Mfg. Co.
4	Governors	Lombard		Speed-control, main units	Belt-driven from generator shaft	Lombard Governor Co.
1	Surge tank	Differential	50x105 ft., 1,400,000 gal.	Regulation of pipe line		The Kennicott Co.
4	Valves	Balanced hydraulic	8-ft.	Controlling penstock water	Hydraulically operated, electrically controlled	Wellman-Seaver-Morgan Co.
1	Crane	Electric	40-ton	Generator room	Motor-operated	Shaw Electric Crane Co.
12	Transformers	Oil-cooled	2200-kv.-a.	Generator to line voltage	Single-phase, 25-cycle, 6600-60,000 volts	Westinghouse Electric & Mfg. Co.
4	Circuit-breakers	Single-throw	7920-kv.-a.	Between generators and transformers	6600 volts, 1200 amperes	Westinghouse Electric & Mfg. Co.
4	Circuit-breakers	Single-throw	7920-kv.-a.	Between transformers and high-tension bus	60,000 volts, 100 amperes	Westinghouse Electric & Mfg. Co.
2	Circuit-breakers	Reactance type	32,000-kv.-a.	Between high-tension bus and line	60,000 volts, 300 amperes	Westinghouse Electric & Mfg. Co.
3	Transformers	Self-cooled	100-kw	Station service	Delta-connected, 6600 to 2200 volts	Westinghouse Electric & Mfg. Co.

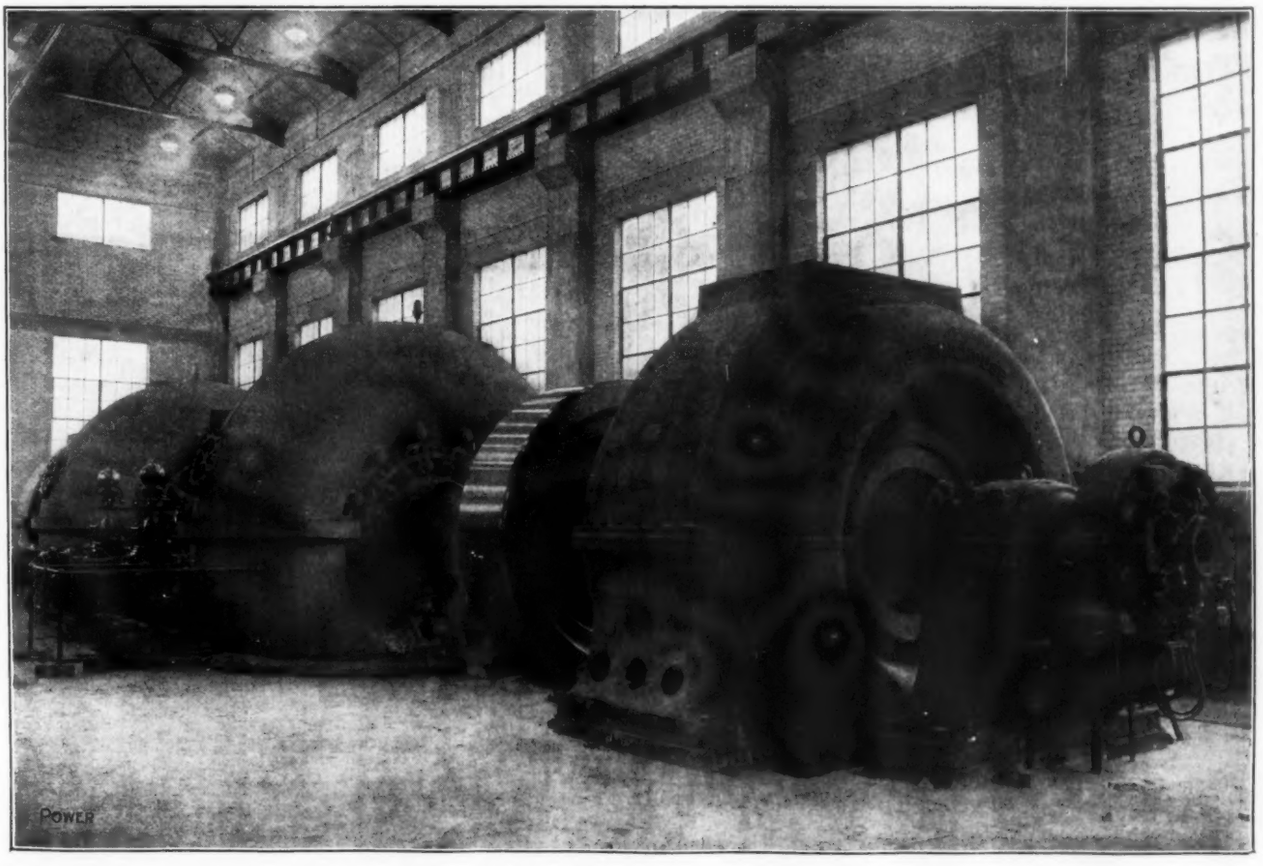


FIG. 14. TWO OF THE FOUR 10,000-HP. TURBINES AND 7290-KV-A. GENERATORS

coils. Directly under the buses are the necessary disconnecting switches.

For station service there are three 100-kw. self-cooled transformers which step the voltage from 6600 down to 220 volts. They are delta connected on both sides.

On the main floor, under the gallery, are the generator circuit-breakers, main and service transformers and a storage battery for switch operation. The control switchboard is on the lower floor of the feeder bay, and is of the vertical panel, remote-control type.

Transmission Line

The transmission line from the power house to the substation of the Niagara, Lockport & Ontario Power Co., at Solvay, N. Y., is about 42 miles long and comprises two circuits carried on steel towers with suspension insulators.

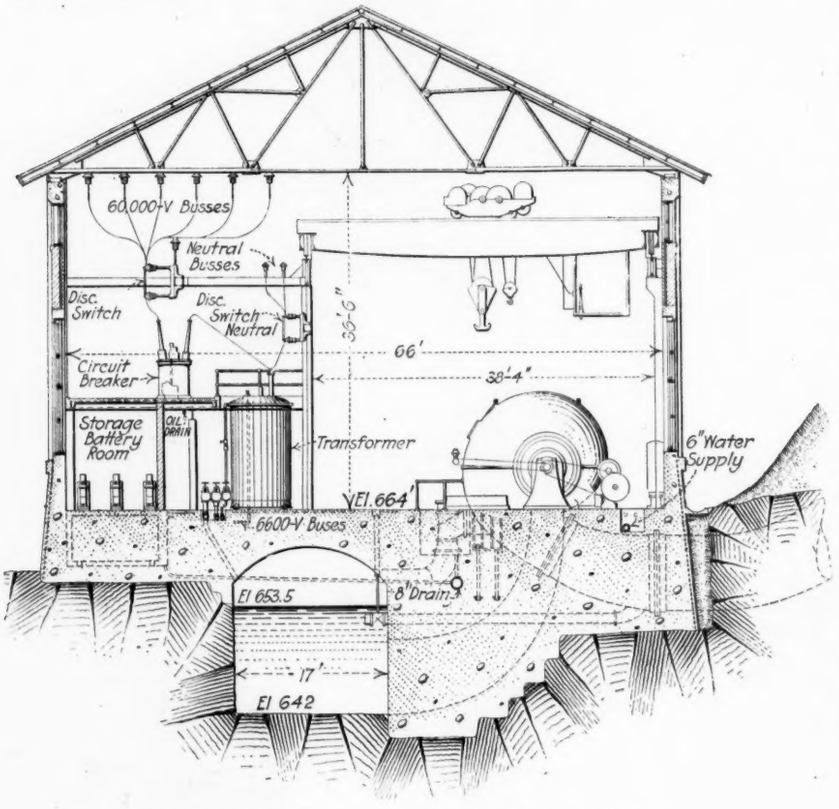


Fig. 15. Elevation of the Power Plant

The plant was first put into commercial operation in April, 1914, with two units running. The third and fourth units were placed in service in October, 1914, and the plant is now carrying a maximum load of 23,000 kw.

The engineering work was carried on under the direction of V. G. Converse, chief engineer of the Salmon River Power Co. Messrs. Barclay Parsons & Klapp had charge of the engineering and construction of the dam, and also acted as consulting engineers for the entire work.

Human Energy in Electrical Units—On an average a man dissipates about 2.5 kw.-hr. per day. This is spent partly in muscular action, partly in the production of heat in the maintenance of the body temperature against radiation. There is thus a continual power consumption of about 100 watts, or one-seventh of a horsepower. About one-half of this is spent in maintaining the body temperature. The human body has about the same heating effect upon the surroundings as a 16-cp. carbon filament lamp.—"Scientific American."

A Low-Pressure Turbine Manifestation

By Ide L. Benedict

Instances are frequent where power-plant machinery has been improperly selected. This may not have been the result of ignorance or misrepresentation, but of failure to give due consideration to the probable operating conditions. Cases of the installation of units of incorrect size are probably more numerous than those in which an unwise choice of the type of prime mover has been made. It would seem that we rely too much upon attaining ideal conditions, when estimating the performance of a new type of machine. There may sometimes be good reason for this and the expectation is realized. On the other hand the conclusion may have been reached from a superficial survey of the operating factors, and the actual results fall far short of the prediction. Examples can be cited of new gas-engine installations of excellent operating record which were soon displaced by steam turbines on account of the rapid increase in the price of gas.

On the advent of the low-pressure turbine too much was expected of it, not only in effecting a remarkable saving in fuel consumption, but also in providing a new lease of life, from an economical viewpoint, for existing engine equipment. While the majority of the low-pressure turbines have been economic successes, there are one or two exceptions from which a lesson may be drawn

First, the low-pressure turbine is dependent upon a favorable vacuum being maintained, and secondly, a good load must be carried upon the unit. Otherwise the potential economy is sacrificed.

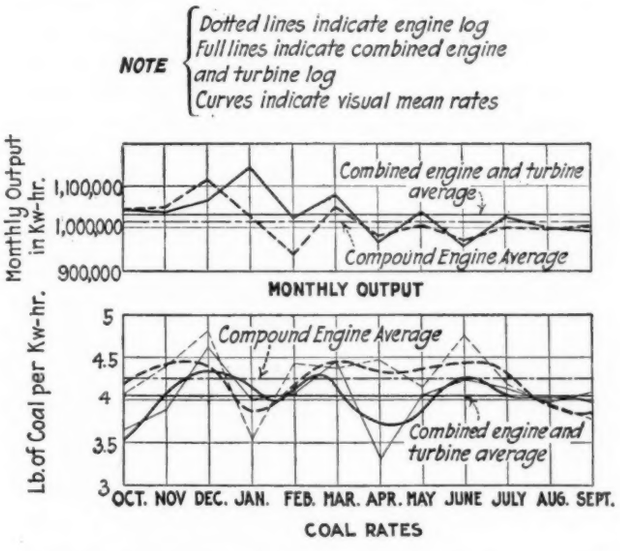
The accompanying curves, taken from the records of such a low-pressure turbine plant exemplify this phase of power-plant engineering and operation. The average saving in coal consumption throughout the year was somewhat less than 4 per cent., representing a reduction from 4.25 lb. to about 4.1 lb. per kilowatt. Under favorable conditions, the low-pressure turbine should effect an improvement of over 25 per cent. and lower the coal rate to 3 lb. or better. An analysis shows that the load is a widely swinging one and the fluctuating condensing-water conditions preclude high vacuum being regularly maintained. Furthermore, the power consumption of the condenser auxiliaries is abnormal on account of the rise and fall of the water-supply level, and as the station furnishes only a direct-current output and the turbine is coupled to an alternator, converting machinery with its attendant losses is required. So the operation of the low-pressure turbine is prejudiced, and it would be an unfortunate commentary upon this type of prime mover if all of these controlling factors were not made clear.

As will be observed, the load on the plant did not vary sufficiently to have any appreciable bearing. The dif-

ference in coal rate from month to month is partly explained by the irregularity with which coal is received.

The curves show twelve months preceding and twelve months succeeding the installation of the low-pressure turbine. Some theories may be advanced as to the reason for the apparent irregularities. The high coal rates obtain at about the same time as the heavy load. As a station's economy should ordinarily improve with an increase in output, the cause for the variation may be due to engines pulling loads at long and uneconomical points of cutoff, or the hand-fired boilers may have been forced to a point where their efficiency fell off rapidly.

Sometimes the winter coal rate will increase on account of the greater radiation losses and the introduction of colder air into the furnaces, if the condensing equipment is not capable of operating on a low-terminal temperature difference, and therefore does not utilize the benefit of the low circulating-water temperatures. But apparently, these circumstances do not exert much bearing in this case. Sufficient measuring and indicating



instruments were not installed to provide for a comprehensive analysis.

In attempting to obtain a clue for these results it may be set down that the variations may follow from such causes as: (1) change in quality of coal delivered; (2) state of repair and adjustment of equipment, proper setting of valves, cleanliness of boiler tubes, leaks, etc.; (3) distribution of load between units, or the operating load factor of the different units; (4) the efficiency of the operators during the periods under comparison.

Visual mean curves have been drawn so as to counterbalance the irregularities in billing the coal and other charges from month to month. The coal rates when running with and without the low-pressure turbine approach each other closely except in April, when a happy set of conditions seems to have been hit upon in the operation of the low-pressure turbine. As compared with the non-condensing engine, the economy of the low-pressure approaches the proper point, taking the maximum dip of the solid line, while in the month of August the comparison is somewhat startling. The station is subject to a rapid swinging of the load over 15 per cent. either side of the mean, and this no doubt has an important effect upon the coal consumption.

The way in which the load divides between the engines and the turbine may account for a good part of the discrepancy, particularly as the entire output of the low-pressure turbine, which is direct-coupled to an alternating-current generator, must flow through a motor-generator set, with a loss of 20 per cent. or more, depending upon the load carried.

Oil and scale on the blades of the turbine would noticeably affect the ultimate economy, but during the period under discussion the turbine was in good condition.

The unit under consideration is of 1000-kw. capacity; steam pressure carried, 150 lb. gage; and vacuum sought, 28 in. (30 in. bar.), though it ranges around 27 in. and less.

In view of this development, which might have been foreseen had these conditions been reckoned with, the natural inquiry is what would have been the most appropriate machine to have installed? The plant was equipped with single-cylinder Corliss engines. Undoubtedly, a straight condensing turbine would have best satisfied the requirements and provided a unit *per se* modern, and would have obviated the perpetuating of the use of the reciprocating engine, as has become necessary with the installation of the low-pressure turbine. Besides, floor space might have been economized, and it would also have made it simple to carry out further extensions both in consistency of type and arrangement.

One thing that should lead to careful consideration in engineering work is that any failure to fully regard all governing conditions will probably be cast up later as a display of lack of ability, and consequently the installation becomes a conspicuous error.

Redesigned Barton Expansion Steam Trap

This thermostatic trap was described in the April 25, 1911, issue of POWER, and was then manufactured by John W. Barton, Cleveland, Ohio. It has been slightly redesigned, and is now manufactured by the Automatic Steam Trap & Specialty Co., Detroit, Mich. The former trap consisted of an inner and an outer expansion tube and a casing holding the two heads. The redesigned trap has but one inner brass tube, an outside steel tube and a valve. A short extension screwed onto the brass tube seats against a flat disk, which is adjustable for different temperatures of steam. In other respects the trap is the same as the original one. The brass tube is free to expand and as its length increases more rapidly than that of the steel tube, when heat is applied it will seat against the disk. Reinforcing rings around the brass tube tend to prevent buckling.

When the trap is first installed the disk is adjusted so that the valve will close when the brass tube is full of steam. When this steam cools into water the brass tube shortens, pulls away from the valve disk and allows the condensation to escape. Steam following the water again expands the tube and closes the valve. This operation is repeated, and the system to which the trap is attached is kept free of water.

Anthracite—When the first two tons of anthracite coal were brought into Philadelphia in 1803 the good people of that city, so the records state, "tried to burn the stuff, but at length, disgusted, they broke it up and made a walk of it." Fourteen years later Col. George Shoemaker sold eight or ten wagon loads of it in the same city, but warrants were soon issued for his arrest for taking money under false pretenses.

Suggestions on Overhauling a Refrigeration Plant

By Thomas G. Thurston

SYNOPSIS—An article alive with practical suggestions for finding the weak and the leak spots in a refrigeration system, and putting the plant in good condition for the next season's run.

The time is here when the demand on the refrigerating system is lowest. Preparations should be made for the time when part or all of the system can be shut down for repairs to put it in good condition for next season's run.

Notes should be made of the defects and troubles that have been contended with during the season and steps taken to remedy them. Joints that cannot be kept tight with reasonable tension on the bolts should be marked for attention when the system is shut down. Leaky valves should receive the same treatment. If the ammonia charge is loaded with oil and impurities, pump it out and have it purified.

The Ammonia End of the Compressor

Open and go over every part of the compressor: Examine the cylinder for shoulders and score marks; see that it is round and of uniform diameter throughout its length. Examine the piston and rings and see that the former is a snug fit in the cylinder and that the rings fit in the piston grooves. See that the rings have sufficient tension; if they have not they can be peened out a little with a hammer, although this is a makeshift. Examine the connection of the piston to the rod and make sure it is firm. Caliper the piston rod and if it is worn or scored have it turned or replaced with a new one.

If the old rod is turned, be sure and make a junk ring for the bottom of the stuffing-box to keep the packing from squeezing out between the smaller rod and the bottom of the box. If the rod is much smaller than the original the stuffing-box gland should be babbitted to about one-sixteenth inch larger than the rod.

If the machine has false heads inspect them and the seats for score marks and signs of ammonia blowing through. Grind them in with emery or powdered glass and oil, or, if they are too bad, they will have to be faced first.

Go over the valves, seats and cages thoroughly. If the valves and seats are not much worn they can be ground in; otherwise, get new ones. See that the valves fit snugly on the guides and that the springs have the proper tension. The correct spring tension can best be determined by the indicator. Any other way is merely guesswork.

In most designs of valves there should be a small hole in the valve or guide to let the latter act freely. If this opening is neglected the gas in the valve or guide will compress or form a vacuum, depending on which way the valve is moving, and interfere with its free action.

Examine the check valve in the discharge; see that it seats properly; grind the valve in or rebabbitt the disk if necessary; be sure that it does not fit too loosely on the guide, for if it does it may hammer and will not seat properly. Clean, oil and grind in the relief valve and see that it works freely. If the suction line has an automatic check valve in it, this should be cleaned and oiled and the valve and seat examined.

Some plants have an elaborate system of piping for oiling the stuffing-boxes and for relieving gas from them. These should be cleaned, as they generally accumulate packing and dirt. Clean out the oil separator; if it cannot be opened it can be fairly well cleaned by blowing it out with a steam hose. Clean, oil and test all the gages. Test all the thermometers if any are used.

The Steam End of the Compressor

The engine cylinder, piston and rod should receive the same attention as similar parts of the compressor. Examine the valves and valve gear thoroughly. Caliper the crosshead guides, and if they are much more worn in the center than at the ends, have them bored or planed. If the crosshead shoes are badly worn they should be babbitted. Caliper the crosshead pins, and if they are not round, have them turned. They may be dressed with a file. See that they fit tightly in the hole in the crosshead. While the machine is dismantled run a line through the cylinders and see how the cylinder guides and main bearings align.

Take the main bearings apart, clean them and see that the oil grooves are open and sufficiently deep. Examine the cranks to determine if they are loose on the crankshaft, or if the crankpins are loose in the disk. When the crankshaft is placed in the bearings be sure to adjust the quarterboxes so that the shaft will line up with the cylinder. After the engine is assembled, adjust the clearance on both the compressor and engine. On an engine and a double-acting compressor this is practically fixed; on a single-acting machine the clearance is adjustable and should be set as close as possible consistent with safety. Some operators have run the piston clearance as low as $^1/_{64}$ in., where the machine is equipped with false heads. The writer believes it should never be less than $\frac{1}{16}$ in.

The Condenser

The condenser should be examined before it is shut down, and all joints that have caused trouble by leaking should be marked. This applies to the joints that may be tight, but have been drawn up with more than a reasonable tension on the bolts to keep them tight. Leaky valves should also be marked. Open a few of the coils, and if there is much oil or foreign matter present they should be cleaned.

Make a steam connection to the gas header, shut off all the gas valves, open the ends of the liquid header or disconnect the coils altogether. Then blow out the coils one at a time by turning steam on the header and opening the gas valves in succession until the oil and foreign matter are blown out. When this is done disconnect

the steam connection and pump about 100 lb. of air pressure on the header and blow the coils as before.

Clean the scale and mud from the outside of the pipes with a wire brush if it is an atmospheric condenser. If it is of the double-pipe type remove the return bends and clean the inside of the pipes with a tube scraper or a turbine cleaner. Open the water headers and clean out the sand and scale that have accumulated in them.

Remove the bonnets from the valves on the gas liquid line and pump out headers. Examine the seats and disks and if they are scored or show signs of blowing through or the babbitt is squeezed out, they must be ground in or rebabbitted. Renew the gaskets on all the bonnets. If it is important to keep the machine running continuously during the season, renew the gaskets between the valves and headers unless certain that the gaskets are in good condition and will not blow out if they start to leak, but may be drawn up without undue strain on the bolts.

The gaskets between the valves and the individual stands are not so important, as a blowout on this side of the valve puts only one coil out of service. For this reason the gaskets between the valves and headers should receive particular attention. If a gasket blows out between the stand and valve or any place in the stand, it is only necessary to shut off the gas and liquid valves, pump out the coil and repair the blowout, when convenient to do so. In the meantime the rest of the condenser may be kept in operation. For this reason it is also important that the valves be tight. The gaskets in the headers should also receive the same attention.

Renew the packing on all the valve stems, also the gaskets in all the leaky joints. Draw up all bolts and if any are rusted so they cannot be turned with reasonable effort, replace them with new ones. Inspect the pipes and headers thoroughly for pitting and corrosion, especially at the water and ammonia joints. If any of them are badly eaten away put in new ones.

Testing for Leaks after Repairing

After everything has been thoroughly examined and repaired, pump an air pressure on the condenser a little higher than the maximum head-pressure carried. This will show bad leaks or joints that have not been tightened. Make thick soapsuds and apply with a brush to all the joints under pressure. Leaks will be indicated by the formation of soap bubbles. After all the leaks that have been found are taken up, pump the pressure up again, shut the discharge valve on the machine and see that the bypass valves are tight, also the blowoff valve on the oil trap and other connections to the discharge line. If there are no leaks and all the valves are tight, the pressure should hold for a long time. If the pressure falls rapidly there is a valve open somewhere or a bad leak, and this must be found.

If the pressure falls gradually, a few pounds an hour, it is generally caused by small leaks that will take up after the condenser is in operation or can be found with a sulphur stick after the ammonia is turned into the condenser.

After the high-pressure test, let the air out of the condenser and pump a vacuum on the latter and let it stand for several hours to see if it will hold; sometimes a line or coil that will stand a high-pressure test will not hold a vacuum for even a short time. About the only way to locate these leaks is to hold a lighted candle to the suspected joint; if it leaks the flame will be drawn in. If the vacuum test is satisfactory, pump all the air possible out of the condenser, and turn the ammonia into it immediately (to keep air from leaking in), until the pressure comes up to five or ten pounds. Now go over every joint with a sulphur stick.

Leaky Water Pipes in Condenser

Tests must now be made for leaky water pipes if it is a double-pipe condenser. The return bends must be off and the sulphur stick held in front and at both ends of each pipe in succession. Corroded pipes must be replaced by new ones.

When the leaks have all been attended to, pump full pressure on the condenser and test it again. If this test is satisfactory put on the return bends and test these and the water headers with water pressure.

Expansion Coils

Unless one is certain that there is no oil present in the expansion coils, it is better to open a few of them and investigate. If there is oil it should be blown out. Make a steam connection to the coils, disconnect all the coils in the case of a brine tank, and first blow each out with steam. If it is desired to remove every trace of oil, pump a solution of caustic soda through the coils after blowing them. In either case they must finally be thoroughly blown out with air.

Renew the gaskets on all the joints opened and tighten the rest. Go over the suction and expansion valves and repair those that may require it. If brine tanks are used, clean them out thoroughly. Pipe hangers and supports around a brine tank deteriorate rapidly and should be looked after. Any of the headers on the liquid or suction sides of the tank that have caused trouble by leaking should be attended to. After the coils have been cleaned, test them as the condenser was tested, although it is not necessary to use as high pressure.

Lines and Auxiliaries

Joints in the lines that have caused trouble during the season should have the gaskets renewed. Remove the bonnets from the stop valves and examine the seats and disks. Note the position of the valves in the line. Nearly all ammonia valves are of the globe or angle type and should be placed in the line so that the flow will lift the disks off their seats in case they come loose from their stems. If the valve is placed in the line in the reverse position and the disk comes loose from the stem, it will act the same as a check valve and stop the flow. This is dangerous, especially in a discharge line. Inspect the lines for pitting and corrosion. If any are rusted badly they should be renewed; if any of the liquid or suction lines are uninsulated they should be covered; if the liquid receiver is in the engine room it also should be covered.

Inspect the brine pump closely for pitting and honeycombing in the surfaces exposed to the action of the brine. The writer remembers one case where the wall between two valve chambers became so weakened from this cause that a large piece blew out and disabled the pump.

A High Boiler Pressure is to be carried on the battleship "Nevada," now nearing completion—295-lb. gage. Oil-fired Yarrow-type boilers will be used.

Retubing Tubular and Water-Tube Boilers

By J. C. Hawkins

SYNOPSIS—Simple and thorough directions for taking out and putting in tubes in various kinds of boilers. What troubles to expect when expanding and beading tubes. How to get a bagged tube through the tube sheet. The use of tools to do this kind of work.

Renewing Tubes in Horizontal Tubular Boilers

The location of the tube to be renewed will govern to some extent the procedure in getting it out. If the tube can be taken out at the lower manhole it can be cut off at both ends inside the heads with a bent chisel or with an inside tube-cutter, Fig. 2. The bead on the outside of the sheet is then cut off with a chisel and the tube ripped through the seat. The ripper, with dimensions, is shown in Fig. 1. In ripping the tubes the workmen should be careful not to cut the tube seat. After the cut is made the ends are closed, Fig. 3, and the piece knocked out. If the tube cannot be taken out at the manhole it must come out through the tube hole.

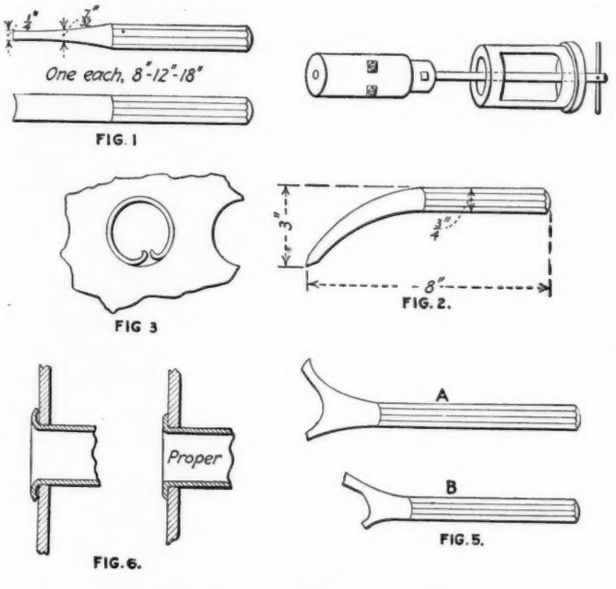
Tubes are usually covered with hard scale and are sometimes bagged or blistered, so it may save time to run the tube-cleaner through the tubes to be taken out. When a tube is to come through the tube hole it is not cut inside, but the ends are ripped and closed up and the tube forced out through the hole.

This may be done in many different ways and the one to be chosen will depend chiefly on the condition of the tube. It may be forced out a few feet with a sledge-hammer and a block of hard wood on the back end, but there is but little room at the back chamber to insert a long block or bar to drive it out. It may be possible to get a flat bar down between the tubes by getting on top of them and swinging the bar against the end of the tube. A chain hoist or block-and-fall hitched to the projecting end of the tube and to the wall will help. If the tube is badly scaled, striking it with a hammer close to the head will help to knock off the scale. Sometimes, turning the tube with a pipe wrench or chain tongs will screw it out of the sheet, especially if a chain hoist is attached to the end to pull it along. After it has been forced part of the way out the projecting end can be cut off with a pipe cutter and a new hitch taken on the remaining part.

As the back end will be battered up in driving the tube out it will not come through the hole without being closed up; this can be done from the outside with a hammer and chisel. Often, more damage is done to the tube hole in getting an old tube out than by working the boiler several years. After the old tube is out the seat is cleaned and the new tube slipped in. Some engineers recommend that the ends of new tubes be annealed in a charcoal fire before putting them in, to make them more homogeneous and prevent them from cracking while being expanded. This is not necessary if precautions are taken to put the tube in properly so that it will not be stretched excessively in expanding.

In some fire-tube boilers copper ferrules are used to fill the space between the tube and the sheet. This is not necessary unless the tube hole has been stretched by repeated expanding. Strips of copper or copper ferrules should be used to fill the space. Whatever the material, it should be softer than the head to prevent stretching the tube sheet. Copper gives the best results. The tubes in a fire-tube boiler should project through the head about one-quarter inch on each end to allow for beading after the tube is expanded. If it extends more than this, the tube is likely to be cracked in beading over. The ends should be expanded tight before beading. Before starting to expand the tube, see that both ends extend through the proper distance, then have a helper hold the front end tight with a bar to prevent it from slipping while the other end is being expanded. In placing the expander in the tube care should be taken to have the rolls extend an equal distance at the sides of the sheet and that the tube expands gradually all around to prevent splitting.

There are two types of expanders—the prosser and the roller, or dudgeon, Fig. 4. The former does its work by a turned taper wedge being driven into the center of a block made up of a number of wedge-shaped sections. The roller expander, which gives the best results and is generally used, consists of a frame carrying three steel



Tools for Cutting and Beading Boiler Tubes

rolls forced out against the tube by a taper plug. The plug is tapped lightly to set the rolls out against the tube and is turned to roll the tube against the seat. If the tube hole is not round the tube will be expanded tight into all the cavities by the roller.

One difficulty sometimes encountered by an inexperienced man in using the roller expander is that when the tube is a loose fit the plug is driven in snug at the start. This will tend to stretch the tube at three points, and when turning the plug the rolls will not move out of these spots. If this occurs the rolls will have to be loosened, set in a different place and the tube gradually rolled until these spots are worked out. Sometimes this

causes much trouble, but if the plug is tightened gradually as it should be, no trouble will be given.

Sometimes the workman is at a loss to know when to stop rolling. As soon as the tube is rolled out tight the rolls will seem to be turning on a smooth surface and the plug will be tight when tapped with a hammer. It is best to stop at that time and examine the joint. If there appears to be spots that are not rolled out tight the expander should be used again. Afer the tube is expanded the ends should be beaded over flat against the head. This can be done best with a beading tool, Fig. 5. The bit of these tools should be about ⅜ or ½ in. wide. Tool *A* is used first to draw the edges over, striking lightly to prevent splitting, and *B* is used to draw it down flat against the tube sheet. Fig. 6 shows proper and improper beading.

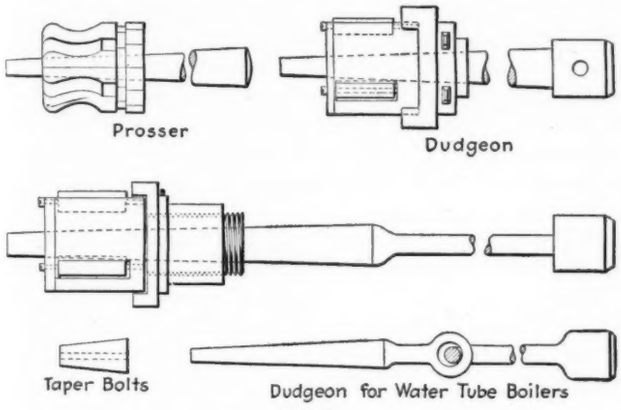


FIG. 4.

TUBE-EXPANDING TOOLS

REPLACING TUBES IN WATER-TUBE BOILERS

Water-tube boilers are built in so many different shapes that no rule applies to all boilers. In the Babcock & Wilcox, Heine and some others of similar design, all the tubes except those in the bottom and top rows will have to come out through the tube hole. Those in the bottom row usually have to be replaced much more often than the others.

The easiest way to get out a bottom tube is to cut it at both ends with the ripper, Fig. 1, made long to extend through the water leg and close the ends up. The tube may then be cut in pieces and easily taken out by cutting it in the furnace near the bridge-wall and again back of the bridge-wall. If the boiler has horizontal baffles on the lower tubes it need not be cut. The most convenient way of cutting a tube is with the five-wheel pipe cutter, Fig. 7, but it may be done with a plain three-wheel cutter by turning the tube with chain tongs. Tubes above the bottom row must come out through the tube hole.

It is a hard job to get bagged tubes through the tube holes. If the enlarged part can be reached with a long chisel between the tubes it may be split and closed up to go through the header. After being driven as far as possible from the back end it will have to be treated in the same way as in fire-tube boilers. It has been necessary, where the tube was badly bagged, to put a clamp on and use a jackscrew on each side to get it out.

Tubes in water-tube boilers are not beaded as in fire-tube boilers, but are "belled" or flared out; that is, expanded to greater than the original diameter outside the header. This is done by first expanding the tube in its seat, then pulling the rolls out so that the end projecting beyond the header, which may be from ¼ to ¾ in., will be expanded to a diameter about ¼ in. larger than the tube. In putting in the new tube care should be taken to replace the baffle brick, which may fall out when the old tube is removed. The best expander for water-tube boilers is made as shown in Fig. 4. This is similar to the plain dudgeon, but the end which carries the adjusting collar enables the collar to be set at any distance from the rolls. The advantage of this is that the center of the rolls may be set over the tube seat irrespective of the distance the tube projects through the header. The plug used in this expander is made long enough to extend through the header to give plenty of room for operation.

The tubes in the vertical boilers of the Wickes and Cahall type are removed through handholes in the head of the steam drum and the new tubes are put in in the same manner as in horizontal water-tube boilers except that the tube must be blocked up in place in the mud drum while the upper end is being expanded and belled.

In Stirling boilers the tubes are so spaced (except in some of the older types) that any tube may be taken out without disturbing any other tube. A Stirling boiler of given horsepower may be high and narrow or low and wide. As the tubes are not all the same shape or length, it is necessary to order them from the makers, stating the type and size of the boiler and for which row they are wanted. The rows are numbered from back to front, No. 1 tube being the one nearest the back wall between the back drum and the mud drum, No. 2 is next toward the grates, etc. They are numbered in the opposite direction to the flow of gases.

To get these tubes out, rip the ends about six or eight inches at the lower end and four inches at the top end. Close up the end and push it down into the mud drum until the top end comes out. Swing it around and pull it out, then twist it around until it will slip out between the other tubes and through the door in the setting. This is sometimes quite a puzzle, but unless the tube is badly warped it will come out easily. The new tubes are marked "Top" on the end that goes into the steam drum and can be put in only one way. Each is also marked with the number of the row in which it belongs. Roll them in as mentioned. They must be blocked up in place and the top end rolled, first being particular to get the bend in line with the others. If this is not done trouble will be experienced in taking out the tube next to it. The first two or three rows next the fire are most likely to give trouble and are generally badly warped. These tubes should be belled in expanding, not beaded.

In any boiler where the seat is in good condition and the tube properly expanded there is small chance of leakage, but as a precaution the boiler should be given a hydrostatic pressure test at one and one-half times the working pressure.

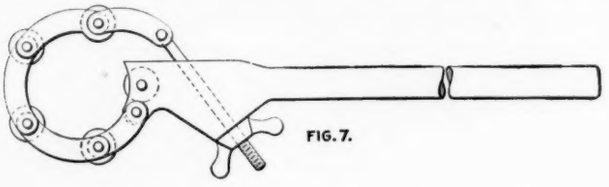
CALKING AND RIVETING

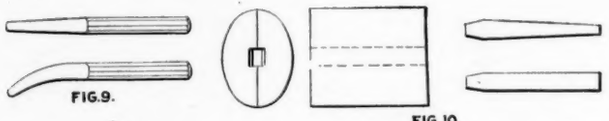
Each time the boiler is out of service the tube ends and joints should be examined for leakage, which usually shows as a grayish-white substance on the fire side of the plate. If the seams appear to have been leaking, they should be calked with a round-nose tool, Fig. 9. The calking should be done while the pressure is off or very

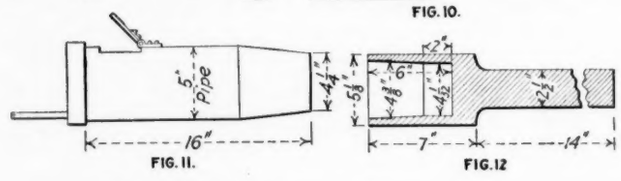
low. If on testing after calking it is found that the leak cannot be stopped, some of the rivets may have to be replaced. If it is a lap-riveted, longitudinal seam the leak may be caused by a lap crack and the inspector should be called in to examine it. Although reriveting may be done by the engineer, it is best to call in a boiler maker. Should the shell over the fire become bagged and require a patch, the job should be turned over to a boiler maker. If the bag is not bad enough to need a patch, it may be driven up by heating it with a blow-torch, beginning at the outer edge and gradually driving it up. Have a template made of the radius of the outside of the shell as a gage.

Replacing Headers in Water-Tube Boilers

At the first glance this appears to be a hard proposition. Renewing a header in a Babcock and Wilcox boiler is no worse than renewing several tubes when they have to come out through the tube holes. These headers are cast steel and must be ordered from the factory, stating the number of tube holes and whether the header is for the front or back end. Sometimes the front headers become cracked at the lower end by the brick below the header falling out, exposing the end to the heat of the furnace, and as the pockets below the lower tube usually contain some scale, the header becomes overheated. A header may be ruined by having a piece cut out of the tube seat in ripping out an old tube.







Tools for Removing Boiler Tubes

In one instance five headers were cracked on the front end and two on the back end, when the blowoff pipe pulled out of the flange fitting, draining the boiler and causing the tubes to overheat. The feed water was on at the time and as this came in contact with the overheated headers they cracked.

To replace these headers an assortment of special tools is required. As the tubes are usually in good condition, except possibly the bottom one, the header is split off the tubes. This is done by a block made to fit the tube cap-hole and split in half, having a taper slot and wedge as shown in Fig. 10. The tube cap-hole is nicked with a chisel at the top and bottom and will usually split from one hole to the next. This leaves the tubes in good order but with the ends expanded. The nipple connecting the top end of the header to the steam drum is then split with the ripper, closed up and then pulled out.

After the old header is removed the ends of the tubes are swedged down to the original size. They are heated in a charcoal furnace, Fig. 11, made of a short piece of 5-in. pipe having one end drawn down to 4¼ in. and the other capped. In the lower side of the cap is connected a 1-in. pipe 3 ft. long to act as a handle and to which the air pipe is connected. A hole in the top of the 5-in. pipe with a hinged cover admits fresh fuel. The air supply is taken from the air-compressor line or other source. A piece of firebrick is placed in the tube about a foot from the end and the heater slipped over the end of the tube. It will only take a few minutes to heat the tube to a bright red.

The swedge used to draw the end down should be made as shown in Fig. 12. This is turned out of a solid piece of machinery steel. The bore is tapered from 4⅜ in. at the mouth to 4 in. at the end of the taper, and straight from there to the bottom. This is driven on the hot tube with a sledge and if driven quickly only one heat will be necessary. To prevent the rear end from being loosened while swedging, block it by bracing to the wall or a solid part of the boiler. After the tube ends are drawn down, all the tube and nipple holes are cleaned out in the new header and it is slipped onto the ends of the tubes, which will have to be raised up and entered with a bar. Two pieces of wood 2x4 in. and about three feet long are made with holes bored to slip over the stud of the tube-hole caps, one in the new header and one on each of the old ones on each side, top and bottom. This brings the header up to place and square with the tubes. Care must be taken to get the header exactly in line, because if this is not done, much trouble may be given in putting in new tubes at any future time; they will bind on the adjacent tubes and will not go through the baffle-walls if the header is crooked.

After the header is in place and properly squared up with the tubes, the nipple holes should be lined up with the throat piece, and also with the mud-drum end if it is a rear header. Sometimes, with these holes in line, the tubes do not sufficiently extend through the holes to allow them to be belled. The cause may be that the header on the opposite end has been pushed out in swedging the tubes and can be sprung back. If this cannot be done, it will be necessary to push the header on farther and roll the nipples in at a slight angle. Cut the nipples from a piece of new tube and expand them in place with the adjustable expander, using the jointed plug shown in Fig. 4. The top end should be expanded first. The bottom end of the top nipple may be rolled through the top tube-cap hole with the jointed plug. In rolling the mud-drum end of the bottom nipples with the loose collar of the adjustable expander reversed to increase the distance between the collar and the rolls, taper rolls are used instead of straight ones. The plug is entered through the lower tube-cap hole. This will bell the projecting end of the nipple. Before expanding the nipple in the header make sure that it is square with the tubes, especially if it is on the front end.

After the work is completed a hydrostatic test of one and one-half times the working pressure should be given. Some of the joints on the opposite end from the new header may show signs of leakage and will have to be re-expanded. This work of replacing headers may be done under the supervision of the engineer.

New Traveling Screens at Delray

By C. F. Hirshfeld*

SYNOPSIS—Endless screens specially designed to simplify the washing operation. If desired they may be washed continuously while in operation.

An interesting installation of traveling screens for screening the circulating water has just been completed at the Delray plant of the Edison Illuminating Co., of Detroit. This plant contains eight vertical-type Curtis turbines with an aggregate rated capacity of around 93,000 kw. The circulating pumps which serve the condensers of these units have an aggregate capacity of about 173,000 gal. per min.

This large quantity of water is drawn from the Detroit River, on the bank of which the plant is built. After flowing through the condensers it is returned to the river at a point farther down stream. At all times of the year the water is apt to contain large quantities of floating and submerged débris of one sort or another, and in the fall of the year it generally carries large quantities of grass and other marine growths which have broken loose from the flats at the lower end of Lake St. Clair and at the entrance to the river. At certain periods large quantities of fish of various sizes also appear at the plant.

To prevent the clogging of pump runners and of condenser tubes, it is therefore necessary to screen the water thoroughly before it is circulated through the plant. Before the installation of the traveling screens this was done by passing the water first through gratings or trash racks and then through vertical screens. A so called screen house is located at the plant end of the intake canal. The water flows through arches under one wall of this house and then through the gratings, which give it a rough screening. These gratings are about 6 ft. in width and

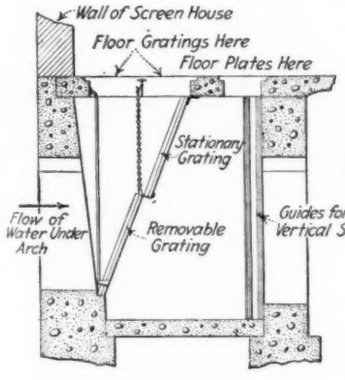


Fig. 1. Arrangement of Screens

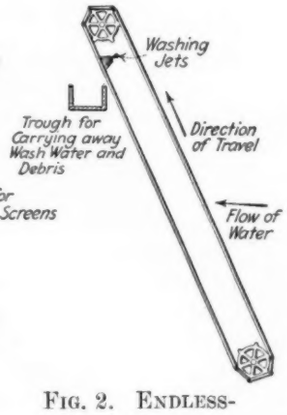


Fig. 2. Endless-Belt Screen

a little over 7 ft. in length. They are made of ⅜x3-in. flat iron bolted together with broad sides adjacent and with ¾-in. spaces between neighboring bars. They are set with the edges of the bars toward the current and at an angle as shown in Fig. 1, two gratings being joined end to end to give a total length, or height on the incline, of about 14½ ft. There are twelve of these units arranged along the length of the screen house. Removable gratings in the floor above facilitate inspection and cleaning.

After passing through the gratings the water strikes the vertical screens. These consist of copper-wire screen fastened upon a rectangular frame made of channel and angle irons. The frames are about 9 ft. wide by about 12 ft. high and are divided into four rectangular panels

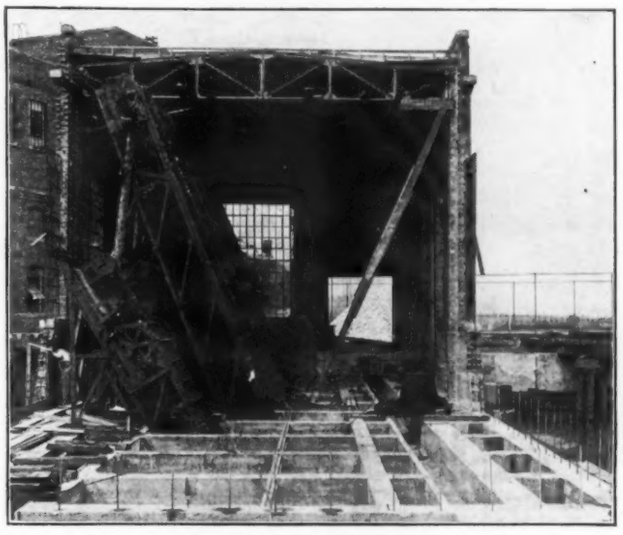


Fig. 3. Screen House Partly Completed

by horizontal and vertical cross-members. Each panel is braced by two diagonals. This construction affords a stiff frame and does not give large unsupported areas of screen. The wire screen is so woven that the mesh is rectangular and the openings measure approximately ¼ in. in each direction.

These screens are arranged in units of two each. The back of one screen of a unit is placed adjacent to the face of the other screen of that unit, thus making the water flow through the two in series. The two screens of a unit are dropped into vertical channels which serve as guides and support them in a vertical position with their lower edges resting on the bottom of the water way. This arrangement makes possible the raising of one screen of a unit for washing without entailing the closing of gates or the passing of unscreened water. There are six of these units distributed along the length of the screen house on a line parallel to that of the gratings already described.

In ordinary operation all of the screens were washed three times per day, but when the water contained large quantities of marine growths it was often necessary to wash screens continuously, and even then the water in the rear of the screens frequently fell to an alarming extent.

When a screen is to be washed, the checkered iron floorplates above it are first raised and moved out of the way by a small hand-operated winch carried on a car rolling on a track laid in the screen-house floor. One screen is then raised by means of a traveling crane and placed in

*Research engineer of the Edison Illuminating Co. of Detroit.

a wash box, which is mounted on wheels and travels along the rails just mentioned. This box is open on the side opposite the rear of the screen when in position, and the screen is washed by means of a fire hose and nozzle which plays the water against the rear of the screen, thus driving out all débris which has been caught in the mesh and forcing all accumulations off of the face or front side of the screen. The wash water, with its burden of trash, flows to waste through a spout fastened to the bottom of the wash box.

The new screens were designed to simplify the washing operation. They can be washed continuously while in operation, if desired. Each unit consists of an endless belt carried over sprocket wheels at the top and bottom of a frame, as shown in Fig. 2. The belts are made of panels formed of a light frame and wire screen similar to that used on the older screens.

The belt can be moved by means of a geared motor in the direction indicated in Fig. 2, the speed being 12 ft. per min. The débris collected on the face of the belt can thus be carried up over the top and down the back and washed off into a trough, as shown in the drawing.

For ordinary water conditions, the screens stand stationary most of the time, each screen being moved and washed once in four or five hours. In case of very bad water, it is, however, possible to wash all screens continuously, thus precluding the possibility of getting low water in the plant because of fouled screens.

Seven of these screens have been installed in a new screen house located over an enlargement in the old intake canal, and there is room for the installation of three more. Each frame with its motor and screen belt forms a unit and is located in a separate compartment or canal between concrete walls. These walls carry inclined guides on which the frame of the unit is supported and on which it can be slid upward and out of the water for inspection, painting or repairs. The passing of unscreened water when a unit is raised is prevented by closing a gate at the entrance to the canal or passage in which that unit is housed.

The screen house is shown partly completed in Fig. 3, with one screen lowered into place and the rest raised in the position they would occupy when being inspected or repaired. The circulating water flows from under the trestle at the right, through the screens, and into the old screen house, which can be seen to the left. The interior of the completed screen house is shown in Fig. 4, with seven screens in operating position.

FIG. 4. SEVERAL UNITS IN OPERATING POSITION

Gripwell Pulley Covering

Gripwell pulley covering is a cement to be used on the face of pulleys to prevent the slipping of the belt and to permit of running it loose. It is applied to the pulley, which has been cleaned with a strong solution of sal soda dissolved in water to remove all grease, etc., in a thin coat with a brush and is then allowed to stand until hard and dry.

In the case of large belts a covering of canvas ¼ in. narrower than the face of the pulley is applied to the latter about twelve inches at a time, and rubbed down hard with the cement until the pulley is covered.

It is claimed for this covering that it prolongs the life of the belt, the bearings and the machinery, that it eliminates the taking up of belts and is waterproof.

This pulley covering is manufactured by the Gripwell Pulley Covering Co., Hollis, L. I., N. Y.

Tantalum is much harder than diamond, as is shown by the fact that the only effect produced by a diamond drill, worked day and night for three days on a sheet of metal 1/32 in. thick, with a speed of 5000 r.p.m., was a slight dent in the sheet and the wearing out of the diamond. When red hot, tantalum can be easily drawn into wire or rolled into sheets.

Direct-Current Armature Winding Principles

By Jacob Gintz, Jr.

SYNOPSIS—Directions for the proper spacing and connecting of coils in both series and parallel windings.

The principle of armature winding is nothing more than placing a number of coils, properly spaced and connected to the commutator, so that they accumulate the induced electromotive force produced in the various coils which are connected in series between the brushes.

There are two types of direct-current windings—lap, or parallel, and series, or wave, windings. These are again divided into classes according to the number of winding elements per slot; that is, if a winding has one element per slot it is called a "one-layer winding," and if it has two elements per slot it is called a "two-layer winding." Two winding elements form one complete coil, and the distance that these two elements are apart depends upon the number of coils and poles and is expressed in the number of winding spaces.

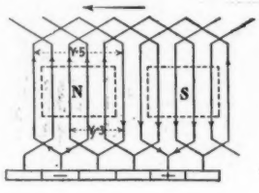


Fig. 1. Front Pitch Less than Back Pitch

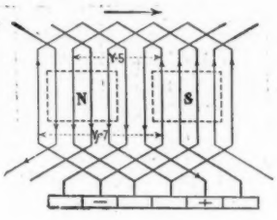


Fig. 2. Front Pitch Greater than Back Pitch

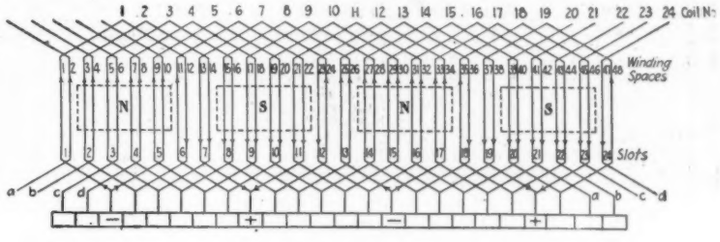


Fig. 3. Winding Laid Out in Accordance with Data in Table 1

When an armature is being prepared for winding, the first step is to insulate the slots, the ends of the core, the shaft and any other parts of the metal with which the winding may come in contact. The materials used for this purpose are fiber paper, shellacked canvas or muslin on the smaller armatures, and on the larger ones, micanite, press-board, empire cloth and various other materials. The coil must be so placed that both its elements do not come under the influence of the same field polarity at the same time, that is, while one side of the coil is influenced by a north pole the other side must be influenced by a south pole. The distance between opposite sides of the same coil is called the pitch, or spread, and is found by the formula

$$\frac{C \pm A}{P} = Y$$

in which C is the number of coils to be placed on the armature, A the number of times the current divides at the negative brushes (once at each negative brush), P the pairs of poles and Y the spread of the coil, expressed in the number of winding spaces. The value of Y must be an odd number. Should it result in an even number, it must be made odd by adding one. If it results in a mixed number, drop the fraction, and if the remaining whole number is odd the value of Y will be the same, even if it is made odd as explained above. This applies to lap, or parallel, windings only.

When the spread of a coil has been found, the distance from the end of one coil to the beginning of another is

$$Y \pm 2 = Yf$$

where Y is the spread of the coil, counted across the back end of the armature (the end away from the commutator) and Yf the front pitch, also expressed in the number of winding spaces, but counted across the front end of the armature. The pitch Yf, however, is not a winding pitch, but merely the distance from the end of one coil to the beginning of the next. In many cases it has been found that instead of considering the pitch Yf, it is easier for the winder to know that the winding is to be placed from right to left or from left to right and that the beginning of the second coil is to be two winding spaces from the first.

There is an advantage when using —2, in that the ends of a coil do not cross one another in connecting to the commutator, thus obviating the danger of short-circuit. When +2 is used the leads will cross as shown in Fig. 2.

In Fig. 1, $Y = 5$ and $Yf = 3$

In Fig. 2, $Y = 5$ and $Yf = 7$

If the connections in Figs. 1 and 2 are applied to two armatures and both are run in the same frame, that in Fig. 1 will run in one direction and that in Fig. 2 in the opposite direction.

In lap, or parallel, windings there will be as many brushes set around the commutator as there are poles in the machine. If such a winding is run with less brushes than poles the entire winding will not be active, and in the case of small machines sparking at the brushes would strongly interfere with operation.

For a practical example of a lap, or parallel, winding consider an armature having 24 slots and 24 coils to be placed in a four-pole machine.

In the winding where there is a like number of coils and slots (each coil being represented by two winding elements) there will be two winding elements per slot, and it will be termed a two-layer winding. There will also be 24 commutator bars, since there must be as many bars as active coils. In a four-pole machine the coils must spread at least one-quarter of the circumference, or 180 electrical degrees. Now find the spread or pitch expressed

in the number of winding spaces, with $C = 24$ and $A = 2$. In lap- or parallel-wound armatures there are as many brushes as poles; then two brushes will be negative and two positive, and as the current will divide once at each negative brush, there will be two divisions of current. Also $P = 2$, since there are 4 poles (one north and one south pole make one pair). Applying the formula:

$$\frac{C + A}{P} = Y, \text{ or } \frac{24 \pm 2}{2} = \frac{26 \text{ or } 22}{2} = 13 \text{ or } 11$$

While it is possible to use either 13 or 11 winding spaces, one spacing having no electrical advantage over the other, it is better to use the smaller value, because it requires less wire to wind the armature, saving material and cost of manufacture.

Having chosen 11 winding spaces for the spread of the coil, then the first coil will be placed in winding spaces Nos. 1 and 12 (11 spaces between). This being a two-layer winding, space No. 1 will be in slot No. 1 and space No. 12 will be in slot No. 6. To locate the beginning of coil No. 2, apply the formula, $Y \pm 2 = Yf$. This will give the number of winding spaces to be counted back from the end of coil No. 1 to the beginning of coil No. 2. Remembering the advantage and disadvantage

TABLE 1

Coil No.	Spaces No.	Slots No.	Coil No.	Spaces No.	Slots No.
1	1 and 12	1 and 6	13	25 and 36	13 and 18
2	3 and 14	2 and 7	14	27 and 38	14 and 19
3	5 and 16	3 and 8	15	29 and 40	15 and 20
4	7 and 18	4 and 9	16	31 and 42	16 and 21
5	9 and 20	5 and 10	17	33 and 44	17 and 22
6	11 and 22	6 and 11	18	35 and 46	18 and 23
7	13 and 24	7 and 12	19	37 and 48	19 and 24
8	15 and 26	8 and 13	20	39 and 2	20 and 1
9	17 and 28	9 and 14	21	41 and 4	21 and 2
10	19 and 30	10 and 15	22	43 and 6	22 and 3
11	21 and 32	11 and 16	23	45 and 8	23 and 4
12	23 and 34	12 and 17	24	47 and 10	24 and 5

TABLE 2

Coil No.	Spaces No.	Slots No.	Coil No.	Spaces No.	Slots No.
1	1 and 8	1 and 4	9	17 and 24	9 and 12
2	3 and 10	2 and 5	10	19 and 26	10 and 13
3	5 and 12	3 and 6	11	21 and 28	11 and 14
4	7 and 14	4 and 7	12	23 and 30	12 and 15
5	9 and 16	5 and 8	13	25 and 2	13 and 1
6	11 and 18	6 and 9	14	27 and 4	14 and 2
7	13 and 20	7 and 10	15	29 and 6	15 and 3
8	15 and 22	8 and 11			

of the minus and plus values of 2 in this formula, then, $Y \pm 2 = Yf$, or $11 \pm 2 = 13$ or 9. Taking the minus value of Yf, which is 9, and counting 9 winding spaces back from No. 12 will bring the beginning of coil No. 2 in winding space No. 3, in slot No. 2. Then, spreading the second coil 11 winding spaces between Nos. 3 and 14 will bring it in slots Nos. 2 and 7. Table 1 indicates the number of the winding space and the number of the slot between which the coils are wound.

By following this table Fig. 3 is constructed. The spacing of brushes, expressed in the number of commutator bars from the toe of one brush to the toe of the next of opposite polarity, is determined by dividing the number of commutator bars by the number of poles. In Fig. 3, 24 bars ÷ 4 poles = 6 bars from one brush to the other.

In connecting the windings to the commutator one should know how the brushes will be set in relation to the polepieces. If they are to be set as in Fig. 4, the beginning of each coil should be connected straight out from the slot to the commutator bar, or if they are set as in Fig. 5, the beginning of each coil will be connected a certain number of commutator bars to the right (in parallel windings only), this number of bars, known as the "lead pitch," being determined by dividing the number of commutator bars by twice the number of poles. If this results in a mixed number it should be increased to the next whole number. The reason for these connections is that when the coils are under commutation they should be in neutral position.

When coil AB, Fig. 4, has moved to the position $A'B'$, its conductors are moving parallel with and are not cutting the lines of force; hence, they will not produce an electromotive force. At the same time the commutator bars, to which the coil leads are connected, are under the brushes C. If the coils were connected as in Fig. 5 with the brushes set as in Fig. 4, it would be impossible to operate the machine, because there would then be a dead short-circuit of the coil whose bars were under the brushes.

In some types of armatures there are two or three times as many commutator bars as there are slots in the armature core, the coils being wound with two or three wires in hand, which is the same as winding so many individual coils and connecting them together as one. There are two methods of connecting the coils to the commutator, namely, in parallel or individually. When two or more coils are connected in parallel it is to do away with the handling of large conductors and to make it easier to wind and shape the coils; in this case there

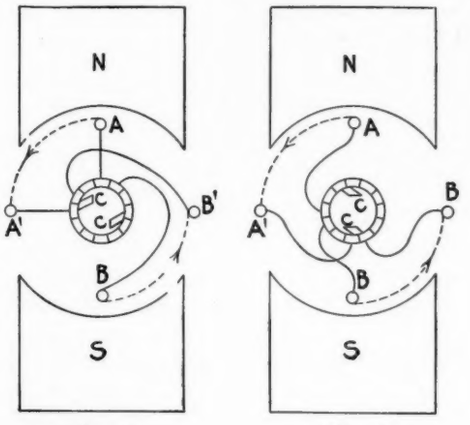


FIG. 4 FIG. 5

WINDING DEPENDENT ON SETTING OF BRUSHES

will be as many commutator bars as there are slots. When there are two or three times as many commutator bars all the coils will be connected separately. This is done to keep the potential between the bars down to a minimum; that is, about 5 volts between bars of machines not exceeding 110 volts, 10 volts between bars of machines not exceeding 220 volts, 15 volts between bars of machines not exceeding 550 volts, etc. These differences in potential apply to both series- and parallel-wound armatures.

The series-wound armature is little different from the parallel-wound armature except in the connections between the coils and the commutator bars.

A wave, or series, winding is sometimes called a two-circuit winding, because it requires but two brushes (one pair) and, as previously explained, there is but one division of current for each negative brush, which is equal to two paths, or circuits. To find the spread, or pitch, of a coil in a series winding, apply the same rule as in the parallel winding, but the value of Y can be any number —odd, even, or a mixed number. Series windings are

divided into two classes, namely, single- and average-step windings, depending on the value of Y. If Y is an odd number the winding will be single-step, in which case Y will equal the commutator pitch (the distance between opposite ends of the same coil expressed in the number of commutator bars). When Y is even it must be made odd by adding one, but the commutator pitch can have two

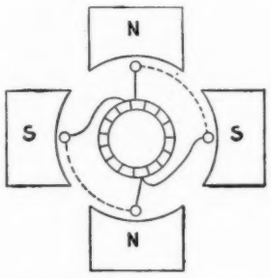


FIG. 6. ILLUSTRATING THE SHORT PITCH

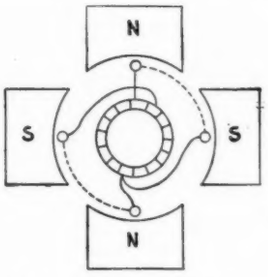


FIG. 7. ILLUSTRATING THE LONG PITCH

values, that is, it can have the original value of Y or it can equal the coil pitch, which was made an odd number, as explained; this is termed average-step winding. The two values of the commutator pitch are called the "long" and the "short" pitch. The short pitch is preferable because it results in fewer crossings of leads from the coils to the commutator. Fig. 6 illustrates the use of the short pitch in a four-pole series winding, showing two coils in series between adjacent commutator bars from right to left, and Fig. 7 shows the long pitch with two coils in series between adjacent bars from left to right.

If a series-wound armature has been connected according to the short pitch and is reconnected with the long pitch, it will reverse the direction of rotation of the armature.

If the value of Y should result in a mixed number the fraction is dropped. In a four-pole winding this can only be ½; in a six-pole winding ⅓, etc. By dropping the fraction there will be an inactive coil, that is, one which will not be connected to the commutator. This, however, will occur only in the older types of armatures, for in the modern designs this has been eliminated, there being an odd number of coils in the winding. In any two-circuit winding it is impossible to connect an even number of coils.

For a practical example of a wave-, or series-wound armature, consider one having 15 slots and 15 coils to be placed in a four-pole machine. This will be a two-layer winding, since there are as many coils as slots, and 15 commutator bars will be required. Then $C = 15$, $P = 2$, and $A = 1$, since only one pair of brushes is required and there will be but one division of current.
Then

$$\frac{C \pm A}{2} = Y, \text{ or } \frac{15 \pm 1}{2} = 8 \text{ or } 7$$

Using the minus value of A, as previously explained (in parallel windings), $Y = 7$. Referring to Fig. 8, this will spread coil No. 1 between winding spaces 1 and 8 (which is seven spaces from No. 1) and it will be located in slots 1 and 4. To find the position of coil No. 2, apply the formula $Y \pm 2 = Yf$. Using the minus value of 2, as explained for parallel windings, $Yf = 5$. Counting 5 winding spaces back from No. 8 will bring the beginning of coil No. 2 in winding space 3 in slot No. 2. Then spread coil No. 2 from space 3 to 10 in slots 2 and 5. Table 2 indicates the number of the winding space and the slots between which the coils will be wound.

The connections between the coils and the commutator are made according to the commutator pitch, which in this problem can be either 7 or 8, as previously explained.

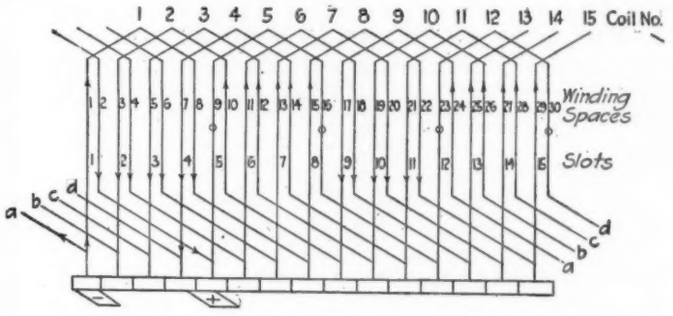


FIG. 8. WAVE WINDING BASED UPON DATA IN TABLE 2

Using the short pitch 7, the coils will be connected as indicated in Table 3.

The spacing of the brushes in Fig. 8 is found by dividing the number of commutator bars by the number of poles; that is, $15 \div 4 = 3\frac{3}{4}$ bars. By placing a negative brush on bar 1 and a positive brush $3\frac{3}{4}$ bars away, which will be between bars 4 and 5, the direction of current through the winding will be as indicated by the arrows. If the windings in Fig. 8 were connected according to the long pitch, the connections would be made as indicated in Table 4.

TABLE 3

Beginning of coil No. 1 to bar No. 1	End of same to bar No. 8
Beginning of coil No. 2 to bar No. 2	End of same to bar No. 9
Beginning of coil No. 3 to bar No. 3	End of same to bar No. 10
Beginning of coil No. 4 to bar No. 4	End of same to bar No. 11
Beginning of coil No. 5 to bar No. 5	End of same to bar No. 12
Beginning of coil No. 6 to bar No. 6	End of same to bar No. 13
Beginning of coil No. 7 to bar No. 7	End of same to bar No. 14
Beginning of coil No. 8 to bar No. 8	End of same to bar No. 15
Beginning of coil No. 9 to bar No. 9	End of same to bar No. 1
Beginning of coil No. 10 to bar No. 10	End of same to bar No. 2
Beginning of coil No. 11 to bar No. 11	End of same to bar No. 3
Beginning of coil No. 12 to bar No. 12	End of same to bar No. 4
Beginning of coil No. 13 to bar No. 13	End of same to bar No. 5
Beginning of coil No. 14 to bar No. 14	End of same to bar No. 6
Beginning of coil No. 15 to bar No. 15	End of same to bar No. 7

TABLE 4

Beginning of coil No. 1 to bar No. 1	End of same to bar No. 9
Beginning of coil No. 2 to bar No. 2	End of same to bar No. 10
Beginning of coil No. 3 to bar No. 3	End of same to bar No. 11
Beginning of coil No. 4 to bar No. 4	End of same to bar No. 12
Beginning of coil No. 5 to bar No. 5	End of same to bar No. 13
Beginning of coil No. 6 to bar No. 6	End of same to bar No. 14
Beginning of coil No. 7 to bar No. 7	End of same to bar No. 15
Beginning of coil No. 8 to bar No. 8	End of same to bar No. 1
Beginning of coil No. 9 to bar No. 9	End of same to bar No. 2
Beginning of coil No. 10 to bar No. 10	End of same to bar No. 3
Beginning of coil No. 11 to bar No. 11	End of same to bar No. 4
Beginning of coil No. 12 to bar No. 12	End of same to bar No. 5
Beginning of coil No. 13 to bar No. 13	End of same to bar No. 6
Beginning of coil No. 14 to bar No. 14	End of same to bar No. 7
Beginning of coil No. 15 to bar No. 15	End of same to bar No. 8

The brushes being set in the same position, the current will be reversed, which would also reverse the direction of rotation of the armature.

If the brushes were set as in Fig. 4, in relation to the poles, the beginning of each coil would be connected straight out from the slot to the commutator bar, and if they were set as in Fig. 5, the beginning of each coil would be swung a certain number of bars to the left (in series windings only), this number being found by dividing the number of commutator bars by twice the number of poles.

In Fig. 8 the positive brushes are set across bars 4 and 5, and as there are as many coils in series between adjacent bars as there are pairs of poles, there

will be two coils in series. Therefore, there will be two coils short-circuited—Nos. 5 and 12, which are marked with small circles.

The formulas employed in this article are somewhat different from those found in textbooks, but they arrive at the same results. A winder will always remember that the winding step Y must be an odd number, and that the difference between any two adjacent coils must be two winding spaces; also, before connecting the winding to the commutator he will find out in which position the brushes are going to be set. This will apply to both series and parallel windings.

Test of Booster Pumps

At the Roseland Pumping Station, Chicago, two booster pumps were recently installed to raise the pressure of 50 to 60 lb., normally carried in the water main, to a maximum of 87 lb. (200 ft.) for the Washington Heights section.

Each unit, as shown in Fig. 1, consists of a 14-in. Worthington horizontal centrifugal pump direct-connected to a 115-hp. Kerr turbine running at 2750 r.p.m., a 325-sq.ft. Worthington cylindrical shell waterworks type surface condenser located in the suction next to the pump, a 5x12x10-in. single vertical flywheel-type air pump with attached hotwell pump, and a 4-in. automatic atmospheric-exhaust valve. The main pumps are of the single-stage, double-suction, screw impeller type with volute casings, and the turbines are each controlled by two governors—a speed-regulating governor and a pressure-regulating governor. The former is of the oil-relay type and the latter of the Fisher type, designed to maintain a constant pressure in the mains regardless of any fluctuations in either the capacity or the suction pressure.

Some of the principal dimensions are as follows: Suction inlet of pump, 13 in. square; discharge outlet, 14 in. diameter (corresponding to a velocity of 7¼ ft. per sec.); steam inlet to turbine, 2½ in.; exhaust outlet, 12 in.; condenser water outlet, 13 in. square, and water inlet, 20 in. diameter. A steam pressure of 170 lb. gage is carried. The manufacturers guaranteed that each pumping unit would develop a duty of not less than 67,000,000 ft.-lb. per thousand pounds of steam at the pressure stated, and not less than 98 per cent. quality when delivering at the rate of 5,000,000 gal. of water per 24 hr. against a head of 85 ft. (not including friction through the pump nor through the suction and discharge piping as measured between the suction- and discharge-pressure gages).

The acceptance tests were conducted by a board of three engineers—one representing the City of Chicago, one the contractor, and the third selected by the first two. In order to vary the capacity and maintain the same constant during each run, the discharge piping system was isolated from the Washington Heights high-pressure system and the water returned to the low-pressure system through cross-over valves controlling the rate of flow. A pitometer was installed about one mile west of the station at a point convenient to the valves mentioned, which were manipulated as necessary to get the desired rate of flow as indicated by the pitometer. This method of regulation permitted constant rates of flow to be maintained, and the temporary isolation of the discharge from the service lines gave the desired freedom from surges which would otherwise have been present in the mains.

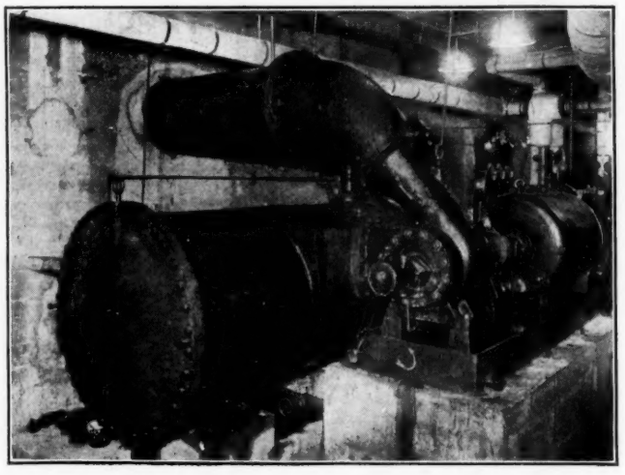


FIG. 1. ONE OF THE BOOSTER UNITS

In accordance with the specifications, the quantity of water pumped during the tests was measured by a 30-in. venturi meter, which is a part of the permanent equipment of the pumping station. The air pump was operated condensing, and the condensate from it was weighed along with the condensate from the main turbine.

The curves in Fig. 2 show the relation between head, capacity and duty through the range covered by the tests, the dotted lines showing the probable performance beyond this range.

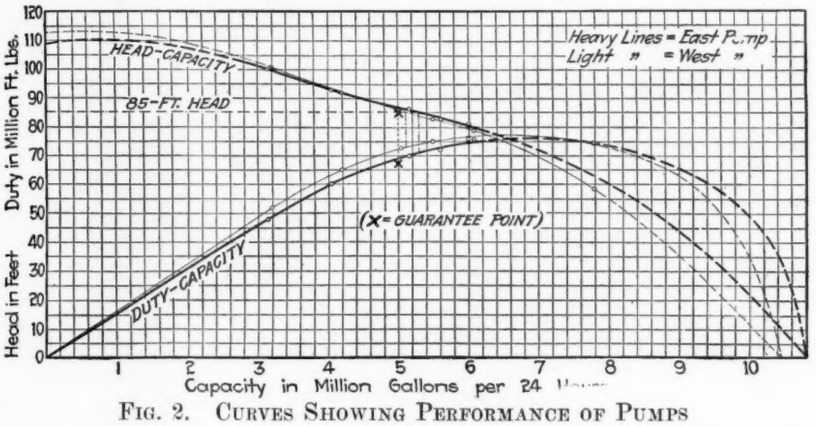


FIG. 2. CURVES SHOWING PERFORMANCE OF PUMPS

The west pump showed a duty of 73,000,000 ft.-lb. per 1000 lb. of steam, corrected to an initial pressure of 170 lb. gage and 98 per cent. dry, and a capacity of 5,120,000 gal. per 24 hr., thereby exceeding the guaranteed performance by 8.95 per cent. in duty and 2.4 per cent. in capacity.

The tests of the east pump, when operating against the specified head at 85 ft., showed an initial duty of 71,000,000 ft.-lb. per 1000 lb. of steam, corrected to the initial conditions, and a capacity of 5,280,000 per 24 hr., thereby exceeding the guaranteed performance by 5.97 per cent. in duty and 5.6 per cent. in capacity.

Editorials

Research and Equipment Engineering

Few engineers are privileged to keep in touch with the progress of laboratory and mathematical investigations in different parts of the world, which affect power-plant development and operation in indirect ways. The reasons are that intense absorption in "practical" problems takes so much time and that research work is conducted for long periods with little publicity because the follower of pure science hesitates to give out results not well established. It is a great mistake, however, to look upon research as a subject of mainly speculative interest, for out of experiments and studies often far removed from matters of routine operation sometimes come developments of immense engineering value.

In a lecture given recently at the Worcester (Mass.) Polytechnic Institute, Professor Albert Kingsbury, inventor of the thrust bearing associated with his name, outlined the steps in lubrication research, extending over many years, which led to the final development of this interesting equipment. Without recounting the sequence of events, it is of interest to note that the most delicate resources of the physical laboratory were drawn upon in measuring the axial eccentricity of a revolving piston fitting closely in a cylinder in which the only lubrication was provided by a film of air about one-thousandth of an inch thick; in studying the wedge effect of rotation upon the lubricant, and in comparing experimental observations with the predictions of Reynolds, whose remarkable mathematical studies of bearing friction, published in the "Transactions of the Philosophical Society of Great Britain" as far back as 1886, threw a flood of light upon many phenomena of obscure explanation noted in the subsequent tests.

The dependence of bearing friction upon speed rather than upon load under these conditions, the practicability of measuring pressure distribution at different points on bearings by multiple gages of the mercury type, the checking of piston displacement by a telephone receiver, setscrew, battery and contact method, taking advantage of the excellent insulation provided by the minute skin of air between the piston and the cylinder, and the study of tool-point lubrication by microscopic observation of cuts in a running lathe, all had a bearing upon the investigation which need not be detailed here, but they serve to point out that it is rash to limit the possibilities of scientific method or to take it for granted that because a phenomenon in friction, thermodynamics or electricity is obscure, it is beyond the reach of modern laboratory apparatus. Few of us need to master the detailed calculations of Reynolds, Lord Kelvin and other savants in the field of mechanical friction, but it is singular and interesting that the experimental results of Kingsbury were so accurately forecasted by mathematical research, which, however, in the case of Reynolds, made the mistake of supposing that the minute quantities involved could not be experimentally measured.

Each type of investigation thus supplemented the other, and the two together ultimately brought forth a useful form of equipment for commercial service, in which the principles determined in investigations which might seem largely theoretical were turned to account in the design and construction of apparatus for power-plant applications. In a broad sense, the final research was a byproduct of a study of the friction of screws—a point worth bearing in mind in observing and recording collateral phenomena in connection with any technical investigation.

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A Suggested Activity for the Engineering Foundation

Few realize the prodigious rate at which additions are being made to available engineering information. In the first place, there are constantly appearing new branches and ramifications to engineering. A half-century has developed electricity into a great industry with an extensive literature, abstract and applied. In a quarter of a century the internal-combustion engine has grown from a driver of coffee mills to one of rolling mills. A couple of decades has seen the evolution of the steam turbine with all the consequent changes in power-plant apparatus and design.

These in our own field; in other fields as great or greater developments have taken place. And with all this, in addition to the fund of knowledge which we have acquired and are still acquiring about the old things, come voluminous contributions to current knowledge about the new. Research laboratories are discovering; committees are investigating and reporting; professors and postgraduates are studying; inventors and developers and manufacturers and users are finding out; professional societies are hunting all who have special information and inducing them to add it to the general fund. The technical press has, for its reason for being, the production and recording of such information. The specialist who a few years ago could get all the available information about his subject in a few standard volumes, the proceedings of a single society, and perhaps a monthly magazine, could now keep so busy reading about it that he would have no time to practice.

In the mass of engineering literature produced, transient as may be the interest of much, subject to criticism and refutation as may be a great deal, duplicative and even contradictory as may be some, there are recorded the accumulated knowledge of and thought upon the subject. If out of this, the material of permanent interest could be put upon record in an orderly fashion, so that the seeker for knowledge upon a particular phase of any engineering subject could find it all together, what effort and time and money would be saved to the delver for facts already known and the traveler upon paths which have been already demonstrated to lead into a dead end.

To what worthier purpose could the trustees of the Engineering Foundation so generously established by Ambrose Swasey devote their initial activities than to the

development of some method of analyzing, classifying and filing engineering information? With sufficient time and talent, a system could be evolved under which the periodicals could print against the titles of articles of reference value or even against individual paragraphs, numbers, of the Dewey-decimal or other system, which would automatically lead these articles or card-index references to them into the right file. The principal reason that this has not been already done is the want of a standard filing system for engineering information.

This is the one engineering purpose in sight which is broad enough to warrant the use of a fund designed "for the advancement of engineering art and sciences in all their branches, to the greatest good of the engineering profession and to the benefit of mankind." And the motion by Henry Hess, in his discussion of the paper by Edwin J. Prindle, dealing with the classifying and indexing of the records of the American Society of Mechanical Engineers, to the effect that it be suggested as an object of their interest and activity, should have been sustained.

One might as well not have a thing as to have it and not know that he has it.

What better use could the means available be put to than in taking stock of current engineering knowledge, classifying and arranging it for ready reference, and organizing a system whereby new information would flow to its appointed place as it develops?

⁂

Analyzing Station Design

The study of generating plant and substation designs is instructive to any engineer. Even if an operating man never expects to lay out a plant it pays him to scrutinize the arrangement and composition of other installations than his own, for it gives him a broader outlook upon local problems and a sense of proportion which is a valuable asset. The more plants one visits, or studies through carefully prepared descriptions in the technical press and in the transactions of engineering societies, the more apparent it becomes that standardization in design is a long way off, and fortunately so. Nearly every installation has some peculiar feature of note, and it is always interesting to weigh and compare the merits of different ones.

A plant recently examined illustrates these points. Situated in a deep valley above a small town, the station is close to the edge of a cliff and utilizes a head of one-hundred feet, with a maximum development of about thirteen thousand horsepower in three direct-connected generating units of modern design supplied with water by a pair of large penstocks leading to the wheels from a dam a short distance above the station. The plant represents a gradual development which has been carried on by its owners with great skill in view of the local difficulties encountered. No criticism of these men is intended in the following comments upon the layout in relation to the latest ideas in hydro-electric development, which are simply advanced to show the importance of viewing installations from the standpoint of trying to see wherein they might be more efficiently arranged were the opportunity to build anew afforded. In other words, it is important to try to determine for oneself whether each installation visited measures up to the most advanced practice known to the visitor, and if not, to quietly study wherein it appears to fall short. This does not mean any failure to appreciate the good points of any layout or to condemn a plant for a few apparent defects for which its present owners and even its original designers may not be responsible, for the art of station design advances as do other affairs, and the best of today soon becomes eclipsed by the practice of tomorrow.

In the case selected, there are industrial plants on the river in the town which utilize eighty feet of additional fall in scattered wheels with both mechanical and electric drives. If the development were to be made today, the existing hydro-electric plant would not be built, but instead, a tunnel would be driven through the hill on one side of the town to the river over one hundred and eighty feet below on the other side of the barrier, and the entire development would be on the basis of utilizing maximum head in concentrated generating units. This would be bold compared with the ideas of the builders of the existing station, but this is the day of bold conceptions in engineering.

Close scrutiny of the present plant indicates the desirability of building a straight operating room free from angles, so that the switchboard can be seen from all points; of bringing the water into the wheels in penstocks which do not obstruct the view in the operating room and the movement of a high-powered traveling crane from end to end; of placing the switchboard where the shortest possible cable runs from the generators will be required that are consistent with good visual control of main units; of providing ample space for oil switches in outgoing lines and straightway runs for high-tension wiring; of placing the chief engineer's office in a commanding position in relation to the operating room instead of in a distant wing of the building without visual connection to the latter; and of avoiding unnecessary complications in high-tension bus and switching arrangements for the sake of a flexibility in operation seldom required in actual service.

Bearing in mind that the design of any station upon which good engineering is expended is more or less of a compromise, it is none the less true that critical examination of such installations pays well for the time and trouble put upon the work, provided at every point effort is made to formulate constructive and not merely captious criticisms.

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That our insistence upon the danger of the breathing head is warranted is again attested by another failure of this sort, this time of a bumped head on a Stirling boiler in New Bedford. Fortunately, the defect was discovered before an explosion or serious damage occurred.

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At the recent investigation of the Public Service Commission of New York for the First District, Travis H. Whitney, secretary of the commission, testified that in the electric-light cases against the New York Edison Co., which have lasted over three years, fifty-two hearings have been held and over one thousand eight hundred pages of testimony taken. The case, he said, has been reopened, not at the instance of the complainant nor the company, but on the application of the Merchants' Association. The company, however, made no objection.

Which is very funny, inasmuch as the application of the Merchants' Association has all the earmarks of having been inspired by the company itself.

Correspondence

Using Graphite in Boilers*

Mr. Weaver's letter in the Jan. 26 issue on the use of graphite reminded me of my experience with it in two or three plants. One plant had three 100-hp. locomotive-type boilers which were heavily scaled. After washing, I put 10 lb. of graphite into each boiler and then fed ½ lb. every twenty-four hours. In three months our boilers were free from scale, and in less than eight months from the date of beginning the use of graphite we had saved about $80 on the coal bill.

It seems to me that engineers expect graphite to act too quickly. It should be remembered that the graphite must get between the scale and the boiler shell and work the scale off by mechanical means. By feeding the graphite in the manner mentioned, a total of 160 lb. of hard scale was removed from a boiler in less than 70 days.

G. A. Bennett.

Denver, Colo.

Mr. Weaver's experience with graphite as a scale remover coincides with mine. I find that graphite and a good mechanical tube cleaner go together. The graphite will soften and loosen the scale and make it easier for the mechanical cleaner to bring it down in either a water-tube or fire-tube boiler. If a boiler is badly scaled it is slow and hard work to get the scale off even after the graphite has loosened it, but the cleaner will break it up and quicken the process of removal.

A. A. Blanchard.

Oxford, N. J.

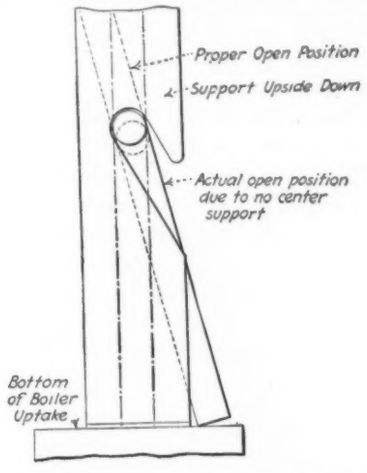
Dampers Would Not Close

The municipal water-works here has four vertical water-tube boilers of 450 hp. each. While the load seldom requires the operation of more than one boiler at a time, two are always under steam in order to provide service in case anything should happen to either boiler. This precaution is necessary, as the pumping engines operate on the Holly system without reservoirs.

During night loads it is advisable to bank one of the boilers. This had been tried on one pair of boilers with fair success. The other pair, however, could not be properly banked. Examination showed that the dampers stuck on the bottom while at the tops they were open as much as four inches. Each boiler has three damper paddles operated on one stem. At one time a strip had been cut from the bottom of a paddle to increase the clearance. This merely aggravated the trouble. Later the center paddle had been tied to the outer ones by straps which slightly bettered conditions.

As this failed to give satisfaction, further examination showed that the stem was bearing at the ends only, the center supports being over the notch for taking out the dampers, and apparently in upside down. The weight of the moving parts caused the damper to settle, strike the bottom first and prevent the top from closing. The more that was chipped off the bottom, the lower the damper sank. The result was inefficient operation when this bank of boilers was in use and a poorer draft when the other bank was on duty, as both are attached to the same stack.

The trouble was remedied by placing a small support under each of the centers between the paddles, thus keeping the bottoms free. The stack now has a much better chance to operate at full efficiency. How much coal went up the chimney since the boilers were installed is problematical. What we do know is that since April, when the station was taken over, the coal consumption has decreased 30 per cent. and the pumps run much slower, in spite of the fact that our meters are reporting more water consumed.



Arrangement of the Damper

H. C. Wight.

Dayton, Ohio.

*See "Power," Jan. 6, Mar. 3 and 31, and Apr. 7, 1914.

A Satisfactory Average Vacuum

In reviewing the many references to the effect of high vacuum on reciprocating engines which have appeared in a long series of volumes of Power, I have been impressed with the omission of consideration of the changeable temperature of condensing water throughout the year. Again and again the disadvantage of larger condensing apparatus, with its resulting high cost, is set down against the gain due to high vacuum, when any such gain is acknowledged at all. I have yet to see a single instance where the question is considered as to whether during the winter time (when high vacuum is available, inasmuch as cool entrance circulating water or injection water makes it so) it is desirable to have air-pumping apparatus of the requisite design and in a requisite state of maintenance, to make the potentially available high vacuum actually existent.

It is, of course, only in recent years that any serious opposition has appeared to the old view that 25 in. or

slightly more represented the most economical vacuum for reciprocating-engine service—an argument apparently based on the widest experience in the days when it was customary for the hotwell water to be used as feed water without subsequent heating with the exhaust steam from independently driven auxiliaries. When this long accepted conclusion began to be questioned there remained a strange absence of any consideration of the possible desirability of keeping the condensing apparatus of moderate size, so that during summer weather only moderate vacuum could possibly be attained, but utilizing steadily increasing vacuum as condensing water becomes colder from summer to winter.

Utilization of this scheme necessitates air-removing apparatus of the best possible operating characteristics. But such apparatus is relatively inexpensive when it represents dry-vacuum pumps used with surface condensers and still less expensive when it represents mere modernized design of jet condensers of the barometric or equivalent form. Why has it not become recognized that a condensing-engine equipment is not installed, and should not be thought of as installed, to maintain some definite and constant vacuum throughout the year, whether it be 26 or 28 in. or more, but as installed is capable of maintaining a certain vacuum in summer and a much higher vacuum in winter, and is to be so operated throughout the year as to maintain as nearly as possible a constant vacuum efficiency referred to the changing vacuum available?

H. L. H. Smith.

Brooklyn, N. Y.

A Puzzling Ground

Several years ago, while operating a substation, I had a peculiar experience with a large booster set used for charging a storage battery and boosting one of the long feeders. The system was Edison three-wire with the neutral grounded; 230 volts across the outside wires and 115 volts to the neutral.

The switches on the high-tension side of the system were remote-controlled, and to operate these, as well as the protective devices on the different units a separate operating busbar was connected across the positive main busbar and the neutral. Fig. 1 shows the connections of the booster and operating busbar.

The first indications of trouble occurred one Sunday, when one of the attendants received a shock while cleaning the booster. Everything on the switchboard was apparently as it should be, so I touched the machine rather gingerly in several places, to see if I could repeat the performance, but without results. With a test lamp I then tested every conceivable place and finally went over the machine with the portable voltmeter, without finding anything wrong.

Everything went along all right for a couple of weeks, when, on Sunday, while making an insulation test the chief found the operating busbar grounded and told me to locate the trouble. To my surprise the operating busbar tested clear, whereupon I decided that the chief had been mistaken and told him so the next day. He maintained, however, that the busbar was grounded when he tested it.

Two days later the chief received a jolt from the commutator of the booster. He was too busy at the time to investigate, but instructed me to do so. Again everything tested clear, only to be followed by the night man receiving a shock from the same machine.

This was getting to be a joke, so I connected a lamp between the frame of the machine and a water pipe to make a ground and placed the lamp directly above the desk so that anyone would be sure to see it in case it should light, for the instant the machine became grounded on either side, the current would flow through the lamp to ground and back to neutral.

One evening, while I was sitting at the desk the light suddenly flashed in my face. I grabbed the test lamp and tested from the positive booster-generator to the frame, but without results. When I applied the test lamp to the negative booster-generator and the frame the lamp lighted up brilliantly. I disconnected the machine from every possible source of potential, even from the operating busbar connections to the speed-limit device, but the lamp burned as brightly as ever. I finally gave up in disgust and sat down to think it over, when suddenly the light went out.

Nobody was near the machine at the time, but the assistant was just switching off the lights over the booster

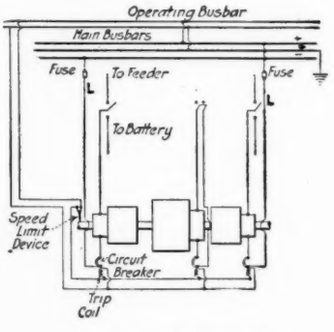


Fig. 1. Booster Connections

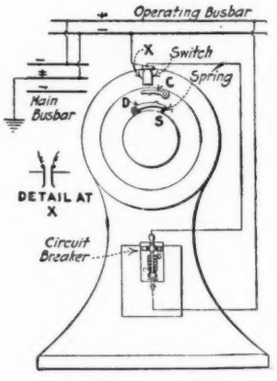


Fig. 2. Speed-Limit Device

set. There was a light over each of the four bearings. These were run in conduits up alongside of each bearing pedestal and clamped to it. I had the lights switched on and, sure enough, the lamp over the desk lighted up again.

One of the light sockets was broken, so this was replaced and the light over the desk stayed out with the machine lights on. I decided that the trouble had been located, concluding that, due to the broken socket, the lighting circuit had been grounded intermittently on the machine.

Two days later, while cleaning the commutator on the negative generator I received a jolt that made me jump. One hand was on the frame at the time, and the other happened to touch one of the brush-holders. The lamp was connected again and lighted up as before. The lights over the machine were out at the time, so it was concluded that they could not be the cause.

A few nights later the night operator again received a jolt from the machine, and at the same time the signal lamp indicated; but he was unable to find anything wrong.

One Sunday, shortly after this, I was sitting at the desk when the light suddenly flashed. The assistant was around the machine at the time and at that particular instant was wiping the end of the bearing and the inside

of the hood over the speed-limit device. I had him go over it again and the signal lamp went out. Evidently the trouble was in the speed-limit device.

Fig. 2 illustrates the construction of this device, in which X represents the contact points or clips of the switch, C is the switch blade hinged on a pin screwed into the main bearing, and D is a weight hinged on a pin fastened to the shaft and revolving with it. Centrifugal force tends to throw this out when the shaft rotates, until at the predetermined speed it strikes the switch blade C, closing the circuit and tripping the circuit-breaker. The tripping speed is regulated by adjusting the tension of the small spring S. It was the switch C that caused all the trouble, for it was not insulated from the pin on which it was hinged; consequently, when the switch closed it grounded the machine.

To complicate matters the switch worked rather stiffly and made contact with one clip before touching the other. In wiping the machine the operator moved the blade C just enough to make it touch one clip without closing the switch, which would have tripped the circuit-breaker. This grounded the machine. Sometimes, due to the jarring of the machine, C would drop down again, or it would stay up until the next time the operator wiped it or sometimes for several days. With the signal lamp connected from the machine to ground, this also grounded the operating busbar.

What made the matter still more puzzling was the fact that the lighting circuit was grounded on the machine at the same time. To remedy the trouble we bored out the hole in C and put in a fiber bushing.

THOMAS G. THURSTON.

Chicago, Ill.

Fixing the Horsepower

A circular issued by the Bureau of Standards points out that at present there is no accepted authoritative definition of horsepower and, therefore, different equivalents of this unit in watts are given by various books. They state that inasmuch as the horsepower is a gravitational unit of power, it varies with latitude and altitude, being 552 ft.-lb. per sec. at the Equator and 549 ft.-lb. per sec. at the North Pole. They recommend the adoption of the horsepower as 550 ft.-lb. per sec. at 50 latitude (approximately that of London) and sea level and that the equivalent in watts be taken as 746.

There are too many engineering quantities for which there are no exact definitions, and it is to be hoped that the engineering societies will adopt standard values. The engineering congress to be held at San Francisco this fall would afford a fine opportunity to settle this and several other values, such as the British thermal unit.

While the writer believes in exact definitions for engineering quantities, he is of the opinion that the Bureau of Standards has over-estimated the commercial importance of the variation of the horsepower with latitude and altitude. It claims that this variation is enough to be of commercial importance and should be taken account of in engineering tests. The greatest error that could occur due to a variation in latitude and altitude is ⅓ of 1 per cent. Practically the only tests made at the present time are to determine the water rate either per indicated horsepower or per brake horsepower.

In the first case the error of the indicator is easily 1 per cent. and the personal error in working up the card can hardly be less than 1 per cent. Other variables, such as weighing the water, etc., will affect the result, so that any engine test can hardly be guaranteed to within 2 to 3 per cent. This would also be true when measuring brake horsepower. It would hardly seem worth while to take into account a variation of less than ⅓ of 1 per cent., when the known error is four to six times as much. This is on a par with boiler tests published from time to time, in which the results are carried out to the fourth and fifth places.

Another quantity which has even more effect on the water rate per horsepower with different altitudes than gravity is the pressure of the atmosphere. Yet the writer thinks that the decrease in back pressure with increase in altitude is not considered of sufficient commercial importance to be taken account of.

W. L. DURAND.

Brooklyn, N. Y.

[Of interest in connection with this letter is the editorial, "The Kilowatt and the Horsepower," on page 720 of the Nov. 17, 1914, issue.—EDITOR.]

Home-Made Feed-Water Heater

The criticism by E. H. Pearce in the issue of Dec. 8, 1914, on page 816, of the total result obtained from a feed-water heater which I described on page 502, Oct. 6, 1914, is entirely just. What I neglected to say was that the first heater gave such satisfactory results that five more were made, some of which were larger than the one described. I regret the blunder very much.

SAMUEL L. ROBINSON.

Providence, R. I.

Probable Cause of Boiler Explosions

Referring to the tabulated list in your issue of Jan. 26 of boiler explosions which occurred during the first half of 1914 and your editorial comment thereon that "these statements (of the probable cause) are not always as full and satisfactory as might be desired" is very true.

Tube failures and other conditions found after the explosions are not the true causes thereof, but are rather the results of conditions for which the tubes should not be held responsible, such as the nature of the feed water—too hard, containing mineral salts and other scale-forming constituents, suspended insoluble matter, or oil which was not filtered out. In the last case, boilers tubes of all kinds are apt to suffer, no matter how excellent they may have been when first put into the boiler.

It has been stated by Messrs. Stromeyer and Barron in a paper before the Society of Naval Engineers of Great Britain, that ⅛ in. of scale will raise the temperature of a boiler plate 300 deg. F., whereas less than 0.001 in. of oil will produce a far worse effect. They also state that the effect of oil is intensified where scale is present, therefore no effort should be spared to keep it out of boilers, not only when slight quantities are found floating on the surface of the feed water, but particularly when the oil is in the so called emulsified condition, as indicated by a cloudy appearance of the water.

There are many and adequate systems now in use to render hard and scale-forming water practically harmless, and also processes which remove every trace of oil from feed water, so that there is no good reason why boilers should be fed with poor water, which is the source of most boiler troubles and serious accidents.

It is to be hoped that state or Federal control will be made more strict in regard to the details gathered relating to boiler explosions, so that no particulars which might throw light upon the true causes of such disasters can be withheld from publicity.

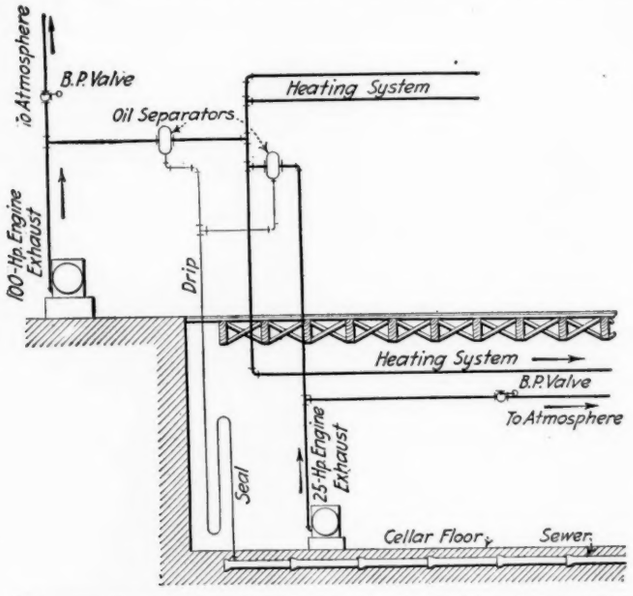
A. E. KRAUSE.

New York City.

Trouble with Oil Separator

Referring to Mr. Goodwin's trouble with the oil separator described on page 207 of the Feb. 9 issue, as I have experienced similar trouble and overcame it successfully, I offer him a solution as per the following sketch.

He states that he carries eight inches of vacuum on his heating system. This will sustain a column of water about eight feet high in the pipes leading from his oil



REMEDY SUGGESTED FOR TROUBLE WITH OIL SEPARATOR

separators, and he should have at least that amount of fall from the bottom of his separator to the top of any seal that he uses. He does not state whether he ever has any pressure above atmosphere, and I take it for granted that he has, so he will need some seal to prevent steam blowing to the atmosphere when such is the case. His sketch shows only sixteen inches of head in one case and practically none in the other.

If he can get no more fall than he shows, it will be better to remove the seals entirely and run a line direct to the sewer with a swing check valve on as low down as possible, opening toward the atmosphere. This will give a head of water over the check to open it against atmospheric pressure, and the check will prevent entrance of air into the system. If he carries a pressure above atmosphere the addition of a steam trap of large capacity will prevent the loss of steam.

His basement separator cannot be given that much fall, but the one on the first floor can be arranged with the seal in the cellar instead of as located, and then it will work. Then he should take the exhaust from the engine in the basement and put it into the heating line at a point near where the other separator enters, moving the basement separator up there, so as to get enough fall to take care of it with a seal in the cellar. I have shown this in a sketch, using only one seal of larger capacity. Perhaps a separate seal for each would be more satisfactory, especially if the separators should be of different patterns or if the piping areas are restricted.

W. F. MEINZER.

Brooklyn, N. Y.

Referring to Mr. Goodwin's inquiry in the Feb. 9 issue regarding trouble with oil separators, the heating system is carrying eight inches of vacuum, which means that a head equivalent to eight inches of mercury, or about eight feet of water, must be carried on the separator side of the seal before the oily drips will overflow the seal.

From the sketch it is evident that the seals are set too close to the separators. My advice would be to run both drips together into a ½-in. lifting trap of the tilting type. When the trap dumps it will cut off the inlet and, consequently, the vacuum of the heating system, allowing the trap to discharge by gravity.

W. L. DURAND.

Brooklyn, N. Y.

Referring to H. G. Goodwin's letter in the Feb. 9 issue concerning "Trouble with Oil Separators," it is suggested that the drip loop in connection with the larger separator should be dropped at least 4 ft. so as to give sufficient head in case of vacuum in the exhaust system, and a ½-in. vent inserted in the top of the last leg of this loop, and a check valve placed at the discharge end near the connection to the waste line. In reference to the smaller separator, it is suggested that the seal loop be replaced with some form of "grease trap" with a check on the discharge side.

CHARLES A. NELSON.

Chicago, Ill.

Chain Oiler Stopped

The oil chain in the outboard bearing on a new gas engine gave much trouble when the engine was first put in service, by stopping and allowing the bearing to get warm unless it was noticed in time and started again before the bearing was dry.

The cap was removed and the chain run around by hand. One joint between two links was rather stiff, but aside from this, there was apparently nothing wrong. The joint was limbered up, the cap replaced, and the engine started again, but before the week was out it was as bad as ever.

Upon a closer examination, the chain was found to be dragging on the bottom of the oil well. Three or four links were taken out, making the chain just long enough to clear the bottom nicely, which entirely eliminated the trouble.

EARL PAGETT.

Coffeyville, Kan.

Safety Devices for Elevator Doors

Now that New York City has a law making it compulsory after a few months to have elevators provided with safety devices on gates or doors, discussion in POWER as to the working of these would be welcome. Several buildings in New York have such devices.

In the building where I am employed there is an electro-mechanical gate lock which has worked well for the last four years. The elevator cannot be started unless all gates in the shaft are closed tightly. When a gate is open a magnet placed over the operating valve (hydraulic car) is energized and, through an arm connected to the lever of the valve, prevents the latter from being moved by reason of the lever being held rigid. To bring out the relative merits of different devices for this service I hope discussion will be forthcoming.

W. T. OSBORN.

Newark, N. J.

[New York City has no such law. A proposed ordinance making the use of such devices compulsory and calling for the inspection of all elevators in the city was presented before the aldermen some time ago, but that body has not yet acted on it.—EDITOR.]

Starting Small Motors

W. S. Grimscom's diagnosis of the trouble experienced in starting a small shunt motor without a starting box when changed from driving a bottle-washing machine to driving a jig saw, referred to in his letter in the Jan. 12 issue, is quite correct, although he might have overcome the difficulty by shifting the brushes. The decrease in the starting torque was caused by the excessive current in the armature which set up a very strong magnetizing force from the neutral points of the armature across the polepieces.

The current in the armature of a direct-current machine produces magnetic poles at the neutral points which cross-magnetize the main poles, weakening the pole tip back of the neutral point and strengthening the one in front, the degree to which the polepieces are weakened and strengthened depending upon the position of the brushes. If the brushes are set slightly in front of the neutral point one is about equal to the other, but if set back of the neutral point the pole tip back of the neutral will be weakened faster than the one in front is strengthened, resulting in a decrease in the field strength. This accounts for the increase in speed of a motor by shifting the position of the brushes backward around the commutator against the direction of rotation. This shifting of the brushes, however, is limited by the sparking at the commutator.

The brushes may be set far enough back of the neutral point to cause no ill effects under normal working conditions, but when subject to an extreme overload current, as in Mr. Griscom's case, the distorting effect may be great enough to weaken the motor or even cause the armature to develop a backward torque.

Mr. Griscom could have remedied his trouble by giving the brushes a forward lead, thus causing the armature current to strengthen the polepieces instead of weakening them. He could also have improved his lamp starting device by short-circuiting it with a single-pole switch after the motor had been accelerated. Furthermore, a starting box could have been secured for this purpose for approximately the cost of the lamps and fittings, not to mention the more satisfactory operation of the driven machine when running under the proper conditions. For a temporary starting device a water rheostat could be used, and this could be made to give as satisfactory results, as far as starting is concerned, as a starting box.

The practice of starting shunt motors by connecting them directly across the line is not to be encouraged except in the case of small, slow-speed machines up to about ¼ hp. running at a speed not exceeding 750 r.p.m. and starting under very light load. If there is liability of the load stalling the motor while starting, a starting box should be used, even under these conditions. In a great many cases where trouble is experienced in the operation of small motors it is from no other cause than improper starting. In small series and compound motors the above rule need not be so rigidly followed, for the series field winding helps choke down the starting current, and as the current increases in the armature it also increases in the series field winding, causing a much greater increase in the starting torque than in the shunt machine, which will accelerate the load more rapidly than is possible with a shunt motor.

A. A. FREDERICKS.

New York City.

Selecting a Pump

In reading the article, "Selecting a Pump for General Service," by Charles L. Hubbard, in the Feb. 9 issue, I was disappointed at not finding more helpful information or suggestions, and more so in discovering a real lack of accurate knowledge and a tendency to erroneous statement.

It is stated that direct-acting steam pumps, engine- and turbine-driven plunger pumps and centrifugal pumps are adapted to conditions where the friction head in the suction pipe plus the elevation does not exceed fifteen to eighteen feet. Should it not be mentioned that a centrifugal pump is not as well adapted where there is a suction head, for it must be "primed" before it will pump water? Sometimes this is a comparatively easy operation, but often it is not. The various methods of "priming" a centrifugal pump might be stated, for certainly the availability of some method of priming might be a deciding factor in the selection of a centrifugal pump.

If the water supply of a power house must be pumped, the distance between the pump and the power house is hardly the only consideration when choosing the type of pump or determining whether to convey steam from the boiler house to the pump or "to drive the pump by an electric motor or gasoline engine" or "to install and care for a special boiler."

In pumping water from artesian wells the air lift is often desirable, but not "to increase the flow." The normal flow of a well cannot be materially increased by any method of pumping, and the air lift is not the type of pump which will always give a maximum delivery from a given-sized hole.

Mr. Hubbard says that "deep-well pumps have an efficiency of 40 to 50 per cent. and a slippage of 10 to 15 per cent." I have used several double-acting deep-

well pumps which showed an efficiency of over 80 per cent. and had no slip whatever. Moreover, these pumps delivered much more water from the well than we could possibly obtain with an air-lift pump.

The statements regarding centrifugal pumps show a surprising lack of knowledge concerning this type, which is so widely used. Their efficiency is given as from 60 to 80 per cent. for the better types, working under the conditions for which they were designed. But, he says, "it is not possible to obtain as high an efficiency as with the best design of piston pumps when the latter are kept in first-class condition." The efficiency of direct-acting piston pumps is given as from 65 to 75 per cent. and of triplex pumps as from 60 to 80 per cent. According to the figures given, the efficiencies of all three types are remarkably similar.

The statement that "turbine pumps are designed for high lifts and are usually compounded in order to reduce the peripheral velocity and thus reduce the friction" is beyond my comprehension. Evidently, the design which characterizes volute and turbine pumps is not clear to Mr. Hubbard, nor is the reason for compounding, as he calls it. High heads require multi-stage pumps, and compounding does not necessarily decrease friction.

L. B. LENT.

Brewster, N. Y.

Vacuum Heating without Thermostats

In an article on "Vacuum Heating without Thermostats," by E. F. Henry, in POWER of Oct. 20, 1914, the author states that "provision is always made for injecting water into the return pipe, so that the pump will not attempt to pump steam." This is a rather broad statement, and in this connection the writer wishes to say that if the traps on the radiators leak steam, then it is necessary to have jet water at the vacuum pump. However, if a properly constructed thermostatic trap is used—and there are such to be had—the necessity for jet water is obviated.

In the article referred to it appears as if the author has the idea that thermostatic traps are altogether impractical. The writer can cite a vacuum installation where the radiators are twenty-odd feet below the vacuum pump, yet the condensation from these radiators is lifted to the pump without the use of jet water. Attention is called to the fact that a twenty-foot lift, including friction in the piping, would correspond to a vacuum of approximately 18 in. At this pressure, water boils at 170 deg. F., approximately. This should reveal the fact that, in case any leakage occurred, the lifting of the condensation would be impossible, since the vacuum line would be quickly filled with steam. The writer can refer to many vacuum systems of heating where no jet water is being used, and where the vacuum pump is quite able to produce a vacuum of from 8 to 15 in.

Mr. Henry is quite right in saying that in some cases a thermostat has been removed without materially affecting the operation of the system. However, in such instances the radiator from whose trap the thermostat has been removed must be located at quite a distance from the vacuum pump, or at a point where the vacuum is low and the discharge from the radiator has ample opportunity to cool before coming to a portion of the return line where a higher vacuum is carried, and even then, trouble is likely to occur.

Theoretically speaking, the substitution of globe valves for the thermostatic trap at the return end of the radiator might work very well, but from a practical standpoint it will be almost impossible to throttle the return from each radiator so that it will allow only the condensation to pass, especially since there is no means of telling just the amount of openings that would be obtained by turning valve handles each a certain distance, because different valves would give different openings. Besides the uncertainty of valve opening it must be remembered that condensation in a radiator may be increased at times as much as 100 per cent. or on the other hand may be so much reduced as to allow steam to blow through. The use of jet water at the pump may prevent the pump from pumping steam, but in such a case the steam is in the return line, up to the point where the jet water enters. In such cases one of the main advantages of a vacuum system is curtailed, to say nothing of the complications usually brought about by the use of jet water, which destroys steam, and it is generally also the case that surplus water has to be discharged from the system.

D. N. CROSTHWAIT, JR.

Marshalltown, Iowa.

We are given to understand by E. F. Henry's statements under "Vacuum Heating Without Thermostats" that he refers to all types of vacuum return valves, although it should be borne in mind that the term "thermostatic" would be more proper, and then strictly correct only when applied to those valves which operate by the expansion of a volatile liquid inside a disk, as distinguished from the float type of valves. His reference to the virtue of the vacuum system as means of abstracting more heat from the steam "before it is thrown away" must be intended to apply only to the use of exhaust steam.

The scheme Mr. Henry proposes has been employed satisfactorily on gravity systems with the return open to the atmosphere and no pump. This is similar to the so called vapor system. With this system, however, a special valve is used that can be shut off and so set, that when it is wide open only the right quantity of steam is admitted to the radiator. This scheme could also be used with a vacuum pump on the return line, provided the difference between the supply and return were always the same—a condition that would be impossible to maintain in practice and would immediately be upset by the least change in either the steam pressure or the vacuum in the return.

With hot-blast heaters, where the rate of condensation changes with every variation of the outside temperature, the scheme would be impractical.

If globe valves are used on the radiators, as suggested, another disadvantage would be that the heating units could never be shut off unless two valves were used.

Taking all points into consideration, I would not advise any engineer to install a heating system and put a vacuum pump on the return line and use no vacuum valves; neither would I advise changing over an existing system with the sole idea of a large saving in operating cost, for there will be none.

W. L. DURAND.

Brooklyn, N. Y.

Electric-Light Rates

When electric plants first came into use they furnished current for lighting purposes only, and their total cost of doing business was, therefore, charged up to the current sold for this purpose. It did not take long to learn that if the same equipment which was installed to provide for light customers could be operating in the daytime, they could afford to sell current cheaper during the day than at night, provided they could continue to charge the cost of doing business up to the light customers. This led to the conception and final birth of the present rate-making "theories."

What citizen or court would permit a street railway to charge a passenger riding on a car during rush hours a fare several times larger than that charged at other times of the day? Can you justly ask a street-car company to charge less for a ride in an owl car just because the load in the power plant at that time is in the valley of the load curve, and because they ought to be glad to have "even a little revenue during that time"?

The electric-light companies seek to show that they are the one exception and that they should be allowed to charge up a greater proportion of their cost of doing business to the small consumer who cannot "kick back," and a lesser proportion to the larger customer who can.

F. F. Chandler.

Indianapolis, Ind.

Vibration Due to Missing Blades

We have in our plant a 100-hp. impulse single-stage turbine running 12,000 r.p.m. The wheel is 24 in. diameter and mounted on a shaft whose diameter is 7/8 in. There are 196 blades on the wheel and the peripheral velocity is, as usual, quite high, being 1256 ft. per second.

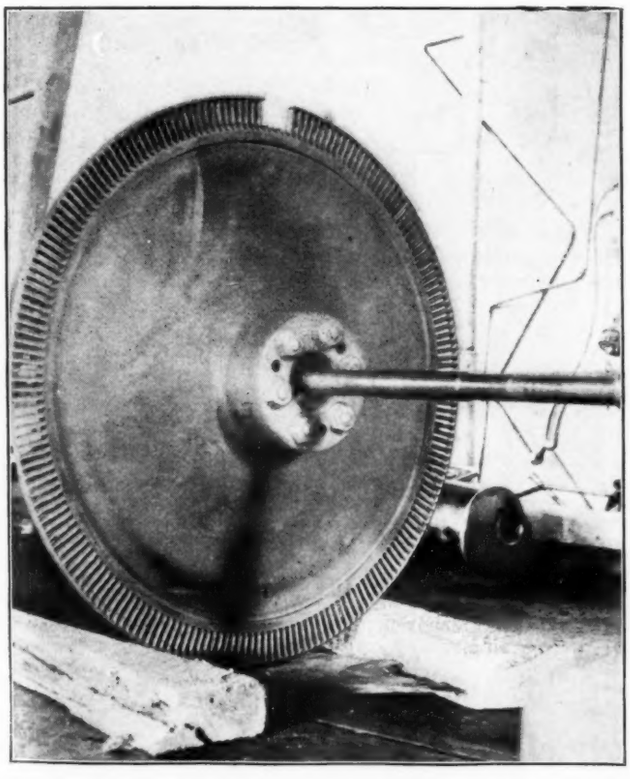


Fig. 1. Turbine Wheel, Single-Stage, Unbalanced by Loss of Four Blades

An examination of the turbine to discover the cause of excessive vibrations of the shaft showed a gap in the rim where four blades had broken off (Fig. 1). Wheels running at this high speed must be perfectly balanced. The loss of a single blade will cause noticeable shaft vibrations.

The blades of these single-stage turbines are made with bulb-shaped shanks which fit into slots in the rim of the disk. The outer ends of the blades are flanged to form a continuous rim of metal (Fig. 2). No special apparatus is needed in replacing the blades. In this case the wheel and shaft were removed from their bearings, the shanks of the broken blades punched out and new blades inserted by driving in from the side. The flanges were then filed true.

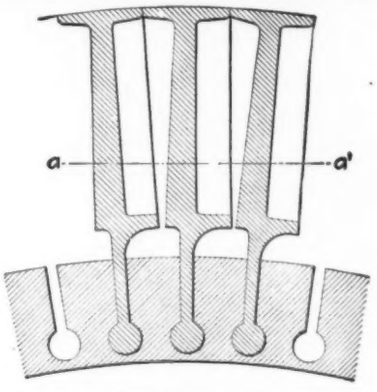


Fig. 2. Section of Blading

Moisture in the steam, small particles of scale, etc., are probably responsible for the breakage. There is no separator in the steam line, though one should be put there.

R. S. Hawley.

Golden, Colo.

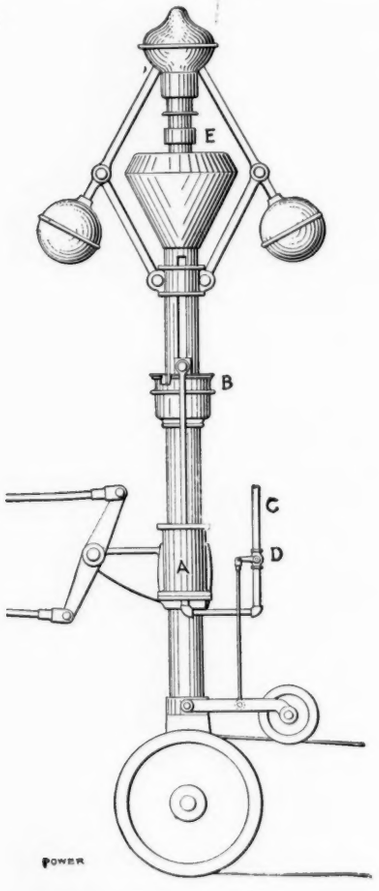
Blocking up the Governor

The direful consequences of blocking up a Corliss engine governor have been so often impressed upon our minds that, with many of us, the faculty of reasoning whether the practice is always hazardous has either never been allowed to awaken or has been quickly inhibited at its inception. The opinion is prevalent that no argument, however reasonable, can justify this practice, and that even to discuss it on the negative side is in itself criminal. Yet there is scarcely any danger—I do not say peril—that cannot be risked with impunity at some opportune time, and certainly there exist conditions under which the governors may be blocked up with comparative if not complete safety. In case of large engines operating under fluctuating loads it is a decided advantage in economy.

Engineers employed in street-railway plants know that, during certain periods of the day, when the peak loads are reached, it is sometimes necessary to prevent the governor weights from dropping below the point of maximum cut-off by fastening up the starting pin. Judging from many an attendant's apprehension at that particular time, however, few seemingly understand that the breaking of a governor belt on one out of two or more engines driving generators connected to the same set of busbars will be attended with little if any evil consequences. Even in industrial plants, in which two or more engines are con-

nected mechanically by means of the factory shafting, the danger is slight provided (and here is where reason and common sense enter) the load is, while the pin is up, at all times equal to, or greater than, the full-load capacity of the largest engine then in operation.

The case is similar to two horses drawing a loaded wagon. One of them may be fresh and impatient, smarting under the restraint of its harness. It prances, jerks and endeavors to run away with the load, but finds it beyond its strength to do so and therefore it is forced to follow the gait of its more conservative brother. Suppose



COMMON FLYBALL GOVERNOR

two engines operating under similar conditions of heavy load, and suppose that the governor belt on one breaks when the starting pin is up. What will happen? Simply this, the other engine will obligingly give the unrestrained one all the load it can take and the latter is immediately forced to adopt the speed of the other engine. It really does not matter whether the governor revolves when the load is so heavy as to bring the weights down on the starting pin.

To sum up, my point is that under conditions as stated an engineer may attend to his ordinary duties with as little concern about his engines as at any other period of the day, and my only justification for so elaborately enunciating it is that we all have enough trouble without borrowing more.

The great danger lies in the neglect to release the starting pin when the load becomes light, and—but this introduces another matter—carelessness, which is not the subject of this writing.

Regarding the one-engine plant, I can only repeat the frequently iterated admonition never to block up the governor unless an independent speed-limiting device is part of the engine's equipment or the ingenuity of the chief engineer has removed, or at least diminished, the certain risk attendant upon the practice. Where necessity spurs, it really is not a difficult matter to devise some scheme to lessen the danger, as the many creditable efforts that have been described and illustrated in power-plant papers prove.

In one plant I was shown an ingenious device which I mention because of its surprising simplicity. The type of governor and the essential details are shown in the illustration. *A* is the oil dashpot, in the bottom of which is inserted a loose piston of a thickness equal to the depth of the step in the movable rest-collar *B*. Leading from below the throttle is the ⅜-in. pipe *C*, which communicates with the bottom of the dashpot and has the cock *D*, whose handle connects with the arm of the idler, as a shutoff.

It is apparent that the arrangement is such that when the governor belt breaks, the idler will fall and open the cock, which, by supplying steam below the loose piston, should force the governor weights to their highest position against the collar *E*. If one will remember that the piston is always lubricated by the oil contained in the dashpot, and that the steam-cock *D* is also prevented from sticking by the same oil seeping past the loose piston into the pipe, I think it will be agreed that its success is probable if the diameter of the dashpot allows of sufficient area. In no way does it lessen the utility of the dashpot.

R. O. RICHARDS.

Framingham, Mass.

Meter and Pump Trouble

In a steam plant using water from the city main the water meter got out of order, the readings being less than they ought to be. The cause was located in the lay-out of the triplex power boiler-feed pump, which had a bypass from the discharge pipe to the suction.

There had been a light load for a couple of months and the temperature of the feed water entering the boilers was higher than at normal load. The bypass was slightly open most of the time, as that was the only way to reduce the water-supply and to get a steady feed. This constant circulation of hot water back to the suction pipe caused considerable heat to get to the meter, which was located near the pump, and put it out of order.

When a new meter was installed two horizontal check valves were placed between the meter and the heater. Later, there was a complaint of a pulsation in the mains of about 12 lb. I connected in the suction line an air chamber made of 4-in. pipe capped on both ends. The lower cap was tapped and made up with a 1½-in. nipple a valve and another nipple screwed into a tee on the suction line. The body of this air chamber was drilled and tapped at the top and bottom for ⅛-in. pet-cocks, and these with the valve kept the chamber clear of water and recharged with air. Since then there has been no pulsation or water-hammer.

JOHN POWERS.

New Bedford, Mass.

Inquiries of General Interest

Calking of Butt and Double-Strap Joint—Where is the calking done on a butt and double-strap boiler joint?

R. G. M.

On the outside along the edge of the narrower strap, where the rivets are close enough together to obtain a good calking pitch.

Steam Lap of Slide Valve—What determines the amount of lap that should be given to the steam side of a D-slide valve?

J. D. P.

The travel of the valve and the angular position of the crank at the time of cutoff.

Delivery in Duty Trials of Pumping Engines—In making duty trials of pumping engines what is the usual method of determining the quantity of water delivered?

A. E. W.

The delivery is usually determined from plunger displacement, after making due allowance for slippage and leakage, which should be ascertained by actual test.

Units of Compression—What is meant by the term "units of compression" as applied to the operation of a reciprocating engine?

S. C. N.

The expression has been used in designating the number of clearance volumes displaced by the piston during its compression of the exhaust. If, for instance, compression of the exhaust begins at the completion of 75 per cent. of the return stroke, then if the clearance is 5 per cent. there will be $(100 - 75) \div 5 = 5$ units of compression.

Cleaning Heating Coils of Grease Deposits—How can steam-heating coils be cleaned of grease that has been deposited by the use of exhaust steam?

W. C. C.

The grease can be removed by filling the coils with a solution of caustic soda made in proportions of about 20 lb. of soda to a barrel of water. The coils should be filled with a warm solution, and after having them filled for about 24 hr. the solution should be drained off and replaced with clean warm water, which should be blown out of one coil at a time with high-pressure steam.

Setting Boilers with Same Height of Tubes—When two horizontal return-tubular boilers, respectively 72 in. and 60 in. in diameter, are set together, should the upper rows of tubes of the boilers be at the same level, so that there will be the same height of safe water level in each boiler?

S. L. G.

There will be no advantage setting the boilers with their upper rows of tubes at the same level, for dependence cannot be placed on maintaining the same water level by connecting the boilers together below water line, as the proper water level must be maintained by regulation of the feed through a feed stop valve for each boiler.

Relative Economy of Engine with Increase of Speed—If the main receiving pulley on a jack shaft is increased in diameter from 72 in. to 84 in., requiring the engine to make nine more revolutions per minute to drive the shaft at the same speed, will not more steam be required by the engine for driving the same power?

E. H.

There will be $^{72}/_{84}$, or $^{6}/_{7}$, as much work required of the engine per stroke and less steam will be required per stroke, and for the same economy the consumption of steam would need to be only $^{6}/_{7}$ as much per stroke, but whether more or less steam would be required per hour for developing the same power would depend upon relative points of cutting off and other conditions affecting economy.

Connecting Two Engines to the Same Receiving Shaft—For obtaining the power of both engines would it be practical to connect a Corliss and an automatic engine to the same receiving shaft?

J. W. D.

For good regulation it would not be practical, as the governors would not synchronize. An approach to ordinary regulation, though only for gradual loading and unloading, could be obtained by adjusting the governor of the automatic engine for carrying the load up to a point where its speed would become reduced to the working speed of the Corliss governor. Then, with the automatic governor blocked against admission of a greater amount of steam, the Corliss engine could pick up any additional load with a reduced speed. But any sudden change of load would give rise to spasmodic variations of speed of unusual extent and duration. Besides the uncertainties of speed regulation there is an additional objection to connecting the engines as proposed, especially when they are widely separated, arising out of the danger of starting up one engine and sustaining a water smash in the cylinder of the other.

Running Shunt Motor as a Dynamo—At what speed will a 30-hp., 115-volt, 120-r.p.m. shunt motor have to be run when used as a dynamo?

H. G. C.

It will have to be run faster as a dynamo than as a motor to deliver the same voltage to the line, because of the drop in the armature circuit. In the motor the speed will be great enough to produce a counter-electromotive force equal to the difference between the impressed voltage and the armature (IR) drop. In the dynamo the speed must be such as to generate an electromotive force which, minus the IR drop, will equal the line voltage.

To solve the problem accurately it will be necessary to know the armature resistance. Assuming this to be 0.08 ohm, then as a motor rated at 30 hp. and 115 volts will have a full-load current of about 165 amp., the armature drop would be approximately

$$165 \times 0.08 = 13 \text{ volts.}$$

The counter-electromotive force would be

$$115 - 13 = 102 \text{ volts}$$

generated at 120 r.p.m. Run as a dynamo, the armature would have to generate

$$115 + 13 = 128 \text{ volts.}$$

Therefore, as a dynamo, the speed would be

$$120 \times 128 \div 102 = 150 \text{ r.p.m.}$$

Changing Speed of Induction Motor—How can the speed of an induction motor be changed?

F. H.

There are five ways in which this may be accomplished, namely: (1) Changing the applied voltage, (2) changing the rotor resistance, (3) varying the number of poles, (4) operating in cascade, and (5) varying the frequency.

The usual means under the first method is the use of a compensator, or autotransformer. This method does not give very satisfactory speed regulation; the efficiency and power factor decrease with the speed.

In varying the resistance of the rotor winding a constant speed is not obtained over the torque range of the machine, but changes with the torque. As in the first case, the efficiency decreases with the speed.

The third method is applicable when only two speeds are desired; as the number of speeds increases, the necessary wiring becomes cumbersome and complicated. The power factor is not appreciably affected in this case, but as it is necessary to open and close the supply circuit in making the change, variation in primary current and fluctuations in voltage are apt to result.

In cascade operation two motors are necessary, the rotors being connected together mechanically. The stator of the first is connected to the supply and its rotor (which is of the slip-ring type) feeds the stator of the second motor; the rotor of the latter is usually connected to an adjustable resistance. This method is frequently used where the speed changes are frequently made, and the horsepower relatively high, such as in electric locomotives. The power factor and efficiency of two motors in cascade are less than a single machine of the same capacity.

The fifth method mentioned, namely, varying the frequency, is usually impracticable. ?

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Just for Fun

[*More stories of stupidity and ignorance competing with "Some Original Ideas," as printed Jan. 19, 1915.*]

While I was employed in a large plant, it became necessary to remove the bonnet of a 36-in. valve. The assistant engineer, the happy owner of License No. 1, was put on the job. The valve bonnet had been unmolested for many years. After he had worked for about one hour, I discovered that he had twisted off 31 of the stud bolts. Two men had to work twelve hours drilling out the studs with a ratchet and "old man" to repair the damage. *Answer*—Always cut the nuts with a chisel. Nuts are plentiful and split easily with the grain of the metal.—*James Browning, Joliet, Ill.*

A few years ago, while I was running a lighting plant in a small country town, a high-school professor visited the plant one night with his class in physics, and asked my permission to explain the electrical apparatus to the boys and girls. I gave my consent after cautioning him to be careful not to let anyone get hurt. Then I prepared to listen to the discourse myself, thinking this would be a good chance to add to my small store of electrical knowledge.

After lining his class up in front of the switchboard, he said, "Now, first we will have a little demonstration in magnetism," and taking a large jackknife from his pocket, before I realized what he was doing he placed it squarely across the main switch. The report and flash that instantly followed were appalling. The professor's hand was badly burned, and the switch had two large scallops melted out where the knife had touched it, and the back springs, handle, and blades of the knife were fused together. The professor explained that he thought the switch would attract the knife.—*C. M. Knowland, Louisville, Ky.*

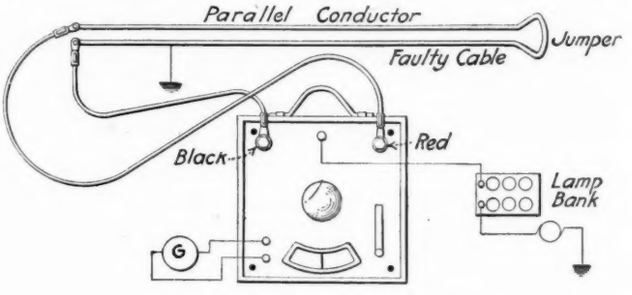
In an artillery electrical plant an officious artillery engineer annoyed the electrician sergeant very much by aimlessly playing with the apparatus. The sergeant, therefore, got some electric primers and concealed them in a cable conduit and connected them to the dead side of several switches, and then found important business elsewhere when the officer appeared again. Of course, the officious one started his usual performance, but very soon heard an explosion, and continuing his monkey business, the noise was soon repeated. He couldn't seem to locate any trouble, and it "got his goat." He hunted up the sergeant and breathlessly said: "I say, sergeant, you'd better go down there and see what the trouble is, for every time I close a switch there is an explosion." And, of course, the sergeant hurried away to make an investigation.

Some years ago a central station in this vicinity was operating several old Thomson-Houston arc machines. A policeman on that beat frequently stepped in for a few minutes. One night he came in looking kind of glum and remarked that he wasn't feeling very chipper—kind of stiff and rheumatic. When no one was looking he took hold of both brushes of one of the arc machines. He said afterward it was pretty harsh treatment, and one dose was enough, but maintained it knocked the rheumatism out of him.—*H. L. Strong, Yarmouthville, Maine.*

Portable Fault Localizer

A portable fault localizer, for quickly locating a ground on an electric cable has been developed by the Westinghouse Electric & Manufacturing Co. The position of a ground is read directly from the dial in per cent. of length of the defective cable. It is an application of the wheatstone bridge, with all the necessary apparatus contained in one portable case wired for connection to the circuit to be tested. Its use assumes that the cable is grounded at only one point and that a parallel conductor of the same length and resistance is available.

After proper connections are made, a dial on the instrument is revolved by means of a knob in the middle of the localizer until the galvanometer shows no deflection when the key is closed. The reading of the meter then gives the percentage of length of the feeder from the point where the test is being made to the location of the ground, assuming the total length of the feeder to be 100



OUTFIT FOR LOCATING FAULTS

per cent.; the red scale indicating that the ground is on the conductor connected to the binding post marked red, and the black scale indicating to the binding post marked black. Direct current only is used in these tests.

The variable-resistance arms consist of two loops of low-resistance wire attached to the side of a revolving disk, upon which the dial is attached, so that contact is easily made from two brushes attached to the case and connected to the galvanometer terminals. As the disk is revolved the point of contact between the brushes and the resistance loops is thus varied, as in the slide-wire bridge. The dial is calibrated in percentage of the length of the conductor tested, so that the reading is direct.

Rules for Thickness and Weight of Lead Pipes

The thickness of lead pipe required to withstand a given pressure may be calculated by the following formula:

$$T = \frac{0.433 \times H \times R}{2745}$$

in which

T = Thickness of pipe in fractions of an inch;
H = Head of pressure in feet;
R = Radius of pipe in inches;

from which we get

$$T = 0.0001578 \times H \times R$$

For lead a factor of safety of 10 is required, hence the last rule becomes $T = 0.001578 \times H \times R$

or, if we take D = the diameter of pipe in inches, instead of radius R, we get

$$T = 0.000789 \times H + R$$

The formula for the weight of lead pipes is

$$W = 3.86\ (D^2 - d^2);\ \text{or}\ 3.86\ (D + d) \times (D - d)$$

in which

W = Weight of pipe per lineal foot in pounds;
D = External diameter of pipe in inches;
d = Internal diameter of pipe in inches;
3.86 = A constant.

Oil Engine for Off-Peak Load

By L. H. Morris

SYNOPSIS—Saving effected in a small municipal plant where an oil engine was installed to handle the load between midnight and 7 p.m., the steam plant handling the evening load.

At present much attention is being given to the oil engine in the West and Southwest, where plants of small and medium size are to be installed. However, it is not alone in new plants that the oil engine finds application, but also in existing steam plants where additional power is necessary, or where a more economical engine is found desirable to handle the off-peak load. This is especially true as regards the small electric-light plants of capacities up to three or four hundred kilowatts, where the load from midnight until morning consists of the street lights and a few residence lights, and where the day load consists of a few motors of small power. In such cases a steam plant of a size to carry the maximum evening load must operate at a low load factor during fifteen to eighteen hours a day, and the resulting cost per kilowatt-hour is often too high to show a fair profit on the investment.

A situation along these lines arose in a municipal light plant with which the writer is connected. This plant, including the pole lines, etc., was purchased from a private company some years ago at a total cost of $35,000. The power house contained a 125-hp. noncondensing Corliss engine belted to a 75-kv.-a. alternator, a 75-hp., high-speed engine belted to a 40-kv.-a. alternator, two 72-in. by 18-ft. and one 54-in. by 15-ft. tubular boilers, together with the usual switchboard, piping, pumps and heaters. A fair estimate of the replacement cost of the plant, including the building, would not exceed $12,000, leaving the outside system to carry the remaining $23,000, less the franchise value; although the entire plant and system could be replaced for less than $20,000.

The load consisted of the lights for the entire town, a few small motors, and a 15-hp. motor driving the city water-works pump. The amount of water pumped was approximately 72,000 gal. per day, the bulk of this being used by the railroads and mill. This pump was thrown onto the line whenever the engineer found the water in the standpipe getting low.

The plant has been under municipal control for about four years, and at no time have the earnings been as large as was expected. This, of course, led to much dissatisfaction and caused the resignation of several plant operators. Finally, there came into office a new set of city officials who were committed to a policy of running the plant on a profitable basis, or of turning it over to a private company.

This ultimately led to an investigation of the oil engine, especially the high-compression type. It was generally understood that the plant required a 150- and a 75-hp. engine. The investigation readily proved that this type of engine would have a high maintenance charge and would require higher-grade engineers than the town could afford to employ, even though the fuel cost be exceedingly low. The medium-compression or semi-Diesel was finally decided upon, but the entire scheme was abandoned upon learning the cost of the two units.

Finally, a new superintendent was employed, who decided to approach the matter in a more systematic way and, therefore, ran a test on the plant with the idea of learning the exact load and the total amount of fuel used per hour.

Curve No. 1, Fig. 1, shows the hourly load for the twenty-four hours. It will be noted that the output is below 40 kw. from midnight until 6 p.m., while from 6 p.m. until 11 p.m. the load is considerable. Furthermore, the crosses marked 1, 2, 3, etc., indicate the hours during which the pump motor was in operation, from which may be judged the load at these hours with the pump motor eliminated (this motor required 13 kw.). Curve No. 2 shows the fuel cost per hour, while curve No. 3 covers the total fuel and labor cost per hour.

An examination of these curves shows that the coal used per hour was out of all proportion to the kilowatt output. It is readily admitted that the excessive fuel charge is open to criticism, and it is self-evident that

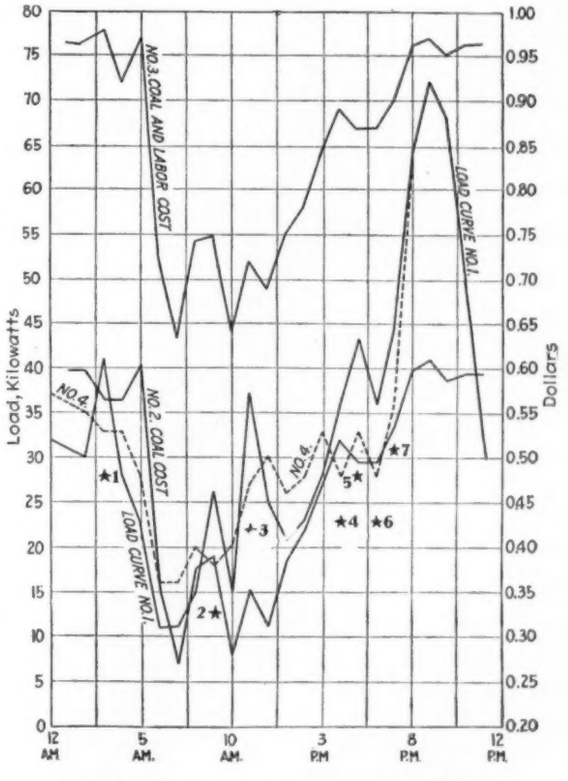


Fig. 1. Hourly Load of Steam Plant

either the engines were in bad condition or the firing was bad. A test on the high-speed engine showed that it used 59 lb. of steam per kilowatt-hour at full load, which, while high, is not excessively so, in view of the belt loss. Furthermore, a casual investigation of the firing method in vogue during the hours of light load indicated that the greater part of the loss was in the boiler room. However, even if the firing conditions had been improved, the

fuel cost would still have been high, because of the varying load.

As already mentioned, the original idea of purchasing two oil engines had been abandoned on account of the cost; therefore, a plan was adopted whereby the plant could use both a small oil engine and one of the steam engines.

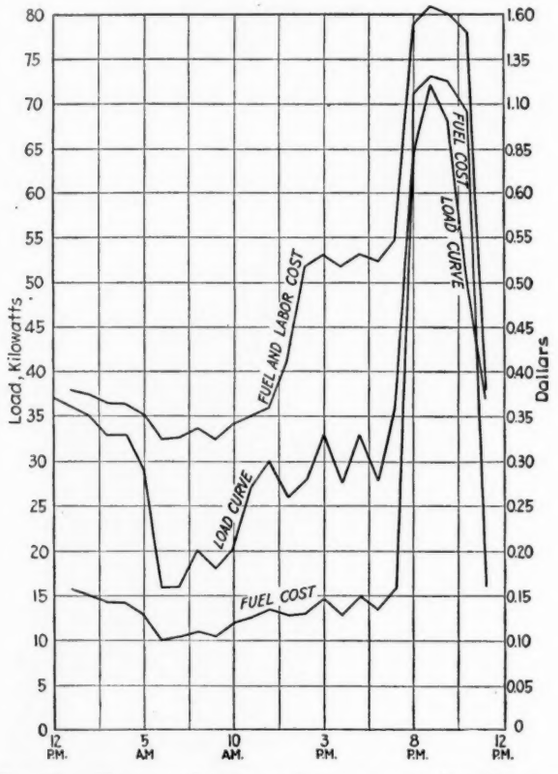


FIG. 2. HOURLY LOAD OF STEAM- AND OIL-ENGINE PLANT

As a means of evening up the load a 4x6-in. duplex power pump was installed to handle the city water, this being driven by a 5-hp. motor operating twenty hours a day, while retaining the centrifugal pump and motor for additional fire protection. This would cause the load to take the form of curve No. 4, Fig. 1. In this way the load would not exceed 40 kw. during nineteen hours of the day; and as the load each day was almost uniform, it could be assumed with safety that this value would not be exceeded for some time to come.

A 60-hp. medium-compression oil engine was purchased at a total installed price of $3800. This engine was of the single-cylinder horizontal type with a guaranteed fuel consumption of 0.067 gal. of desulphurized fuel or crude oil per horsepower-hour, and furthermore was to have a 25 per cent. overload capacity. This was belted to the 40-kv.-a. alternator already installed.

The setting of one of the 72-in. by 18-ft. boilers was altered so that oil could be used as fuel. This involved but slight expense, as the alterations consisted of building a checkerwork of firebrick on the bridge-wall and of covering the grates with a layer of cinders and firebrick. This type of furnace is not ideal for the use of oil, but is one quite generally used where there is a possibility of changing back to coal. Some time in the past the plant had used oil as fuel when it could be obtained at 70 to 80c. per barrel, and consequently it was not necessary to purchase a burner, pumping outfit or storage tank.

The plan of operation was to run the oil engine from midnight until 7 p.m. and then cut in with the steam engine, it being easy to raise steam in about thirty minutes. The oil cost 3c. per gallon delivered. Very little oil was actually used under the boiler from 11 p.m. to 12 p.m., as the steam was allowed to go as low as 50 lb. during this hour, so that the oil saved here made up for the oil used in steaming up between 6 p.m. and 7 p.m. This saved about 1000 lb. of coal that would have been used in banking fires and steaming up.

With this method of operation it was possible to dispense with one man and to raise the salaries of the two engineers. The night engineer worked from 7 p.m. to 7 a.m., the day engineer from 7 a.m. to 7 p.m., while the fireman's hours were from 12 noon to 12 midnight. This allowed two men to be on duty during the heavy load when the steam plant was in operation, and also gave the day engineer time to do repair work each afternoon.

As regards the total saving; it was impossible, of course, in ordinary operation to find any one day's load which corresponded exactly with the day's run plotted in Fig. 1. Consequently, arrangements were made to run a twenty-four-hour test on a Sunday, wherein each hour's load was made the same as on the first test with the exception of the waterworks load, which was distributed over twenty hours instead of seven.

Accordingly, on Saturday night the standpipe was filled, a water rheostat was arranged for manipulating the load and at midnight and each hour thereafter the load was kept to the proper value. It was thought best not to run the pump motor, as it was necessary to take care of the commercial load, which might be slightly larger than during the former test.

Fig. 2 shows the results of the test plotted as to load, fuel cost and total cost. The oil engine, while handled by the city employees, did not come up to the guarantee, but the ease of operation and apparent reliability more than offset the increased fuel consumption. The steam plant used a large amount of oil per kilowatt-hour, causing the fuel cost to be much higher during the peak hours than it was during the corresponding hours of the first test. However, all banking of fires was avoided, with a resultant saving of fuel, and all things considered, the oil proved more satisfactory.

For comparison, the costs per day under both conditions are given below, showing a net saving of $2209.70 per year, which represents a return of 57½ per cent. on the cost of the oil engine and the alterations to the boiler. As soon as the city can raise more funds, a larger oil engine will undoubtedly be installed.

	Steam Plant	Steam and Oil
Fuel: coal at $1.80 per ton, oil at $0.03 per gal.	$11.60	$7.29
Labor: 2 engineers at $72 per month, 2 firemen at $60	8.80	
2 engineers at $80, 1 fireman at $60		7.33
Total cost per day	$20.40	$14.62
Net saving per day		$5.78
Net saving per year		2209.70
Cost of engine and alterations		4200.00
Cost less value of old steam engine		3850.00
Saving on investment		57½ per cent.

The amount of lubricating oil was practically the same on each test owing to the bad condition of the high-speed engine.

Machining a Piston Ring

By G. Strom

A piston ring with a plain surface will wear to its bearing in four or five hours if properly made and fitted. The real cause of leakage is distortion of the ring in manufacture. Fig. 1 shows some of the effects of such distortion.

To produce a properly fitting piston ring, a casting of the required dimension is secured. A spider with the same number of screws as there are jaws in the chuck is then inserted and the screws tightened slightly, Fig. 2; this is to prevent springing the casting when chucking. The casting is then placed in a lathe, chucked upon the spider screws and end *B* faced true. Holes *H* are drilled for bolts or tapped for capscrews for bolting to the faceplate. This must be faced true. The casting is machined to the required dimensions, allowing $\frac{1}{32}$-in. thickness and width for re-turning. In both machining and cutting-off operations the tools must be kept sharp, otherwise the ring will have a wind impossible to remove.

The ring is then placed on an expansion chuck, Fig. 3, to have its sides faced as follows: Place the ring, which should be a sliding fit, on the expansion disk, loosen the four capscrews slightly, press the ring against the chuck plate with a board, tighten the taper plug and the capscrews and then all is ready for facing. Three light cuts are required on each face, using $^1/_{100}$-in. feed.

After both sides of the ring are finished it is split diagonally, using a hacksaw or milling cutter, and fitted into a chucking fixture *G*, Fig. 4, which is $\frac{1}{16}$ in. larger in diameter than the finished ring and is relieved $\frac{1}{8}$ in. for one-sixth of the circumference opposite which the cut in the ring is placed. This is to allow the points to spring slightly outward and when turned off will prevent the points from "digging" into the cylinder.

The fixture with the ring inside is put on the special faceplate *P* and tightened. The chucking fixture is then removed and the face of the ring turned. Only one ring at a time should be chucked; if several are placed together they will buckle and be spoiled. A diamond-pointed tool should be used with a $^1/_{100}$-in. feed per revolution. Three cuts should be taken across the ring with a sharp tool, allowing $^6/_{1000}$ for the finishing cut. The finished ring should be the diameter of the cylinder plus $^1/_{1000}$ for wearing in, and no filing is necessary. The piston should have dowel pins to keep the ring from rotating. In slipping the ring on the piston and into the groove a tin shield should be used instead of wire nails, and the like, as is sometimes done.

In fitting new rings no allowance need be made for circular expansion. This will leave the joints tight when the ring has worn to a bearing and there will be no blowing or leakage.

It might be argued that so tight a ring would score and cut itself and the cylinder. This is not true. A tight piston will quickly score its cylinder, but a tight ring will not. The foregoing is for rings ranging from 3-in. to 18-

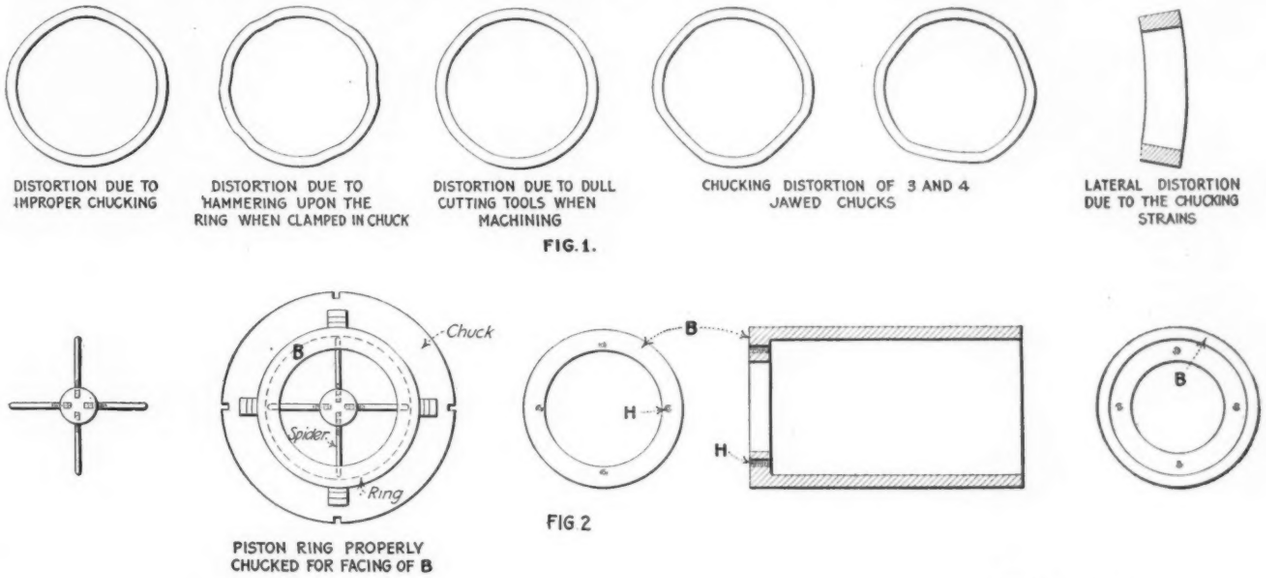

DISTORTION DUE TO IMPROPER CHUCKING
DISTORTION DUE TO HAMMERING UPON THE RING WHEN CLAMPED IN CHUCK
DISTORTION DUE TO DULL CUTTING TOOLS WHEN MACHINING
CHUCKING DISTORTION OF 3 AND 4 JAWED CHUCKS
LATERAL DISTORTION DUE TO THE CHUCKING STRAINS

FIG. 1.

PISTON RING PROPERLY CHUCKED FOR FACING OF B

FIG 2

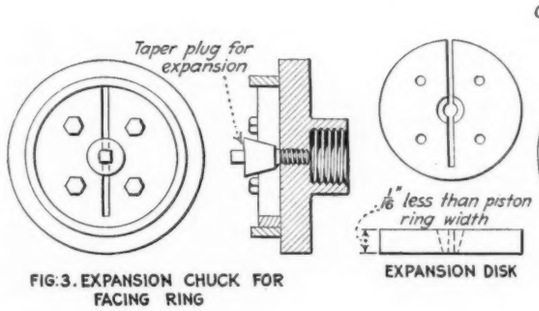


FIG. 3. EXPANSION CHUCK FOR FACING RING

EXPANSION DISK

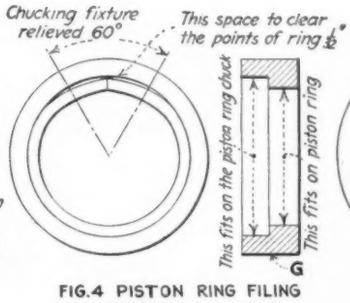

Chucking fixture relieved 60°
This space to clear the points of ring 1/2"
This fits on the piston ring chuck
This fits on piston ring
G

FIG. 4 PISTON RING FILING AND CHUCKING FIXTURE G.

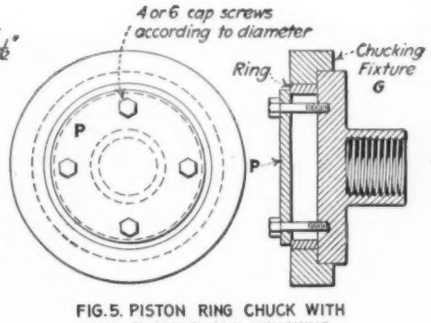


FIG. 5. PISTON RING CHUCK WITH RING, PLATE P, AND CHUCKING FIXTURE IN PLACE

Process of Machining Piston Rings and Some Distortions

in. diameter and 1/8 to 7/16 in. thick and from 3/16 to 1 in. wide. The following table gives the dimensions of several sizes of rings and the allowance for tension.

PISTON RING DIMENSIONS

Diam. of Finished Ring, In.	Width of Finished Ring, In.	Thickness of Finished Ring, In.	Diam. of Ring before Splitting, In.	Allowance for Tension on Ring, In.
18	1	7/16	18 3/16	3/16
17	1	7/16	17 3/16	3/16
16	1	7/16	16 3/16	3/16
15	1	7/16	15 3/16	3/16
14	1	7/16	14 3/16	3/16
13	1	7/16	13 1/4	1/4
12	1	7/16	12 1/4	1/4
11	1	7/16	11 1/4	1/4
10	1	7/16	10 1/4	1/4
9	1	7/16	9 1/16	1/16
8	7/8	7/16	8 1/16	1/16
7	7/8	7/16	7 1/16	1/16
6	7/8	7/16	6 1/16	1/16
5 1/2	3/4	7/16	5 1/16	1/16
5	3/4	7/16	5 1/16	1/16
4 1/2	3/4	7/16	4 1/16	1/16
4	3/4	7/16	4 1/4	1/4
3	7/16	3/8	3 1/4	1/4

Extension of the Dunston Station

The much discussed Dunston Station at Newcastle-upon-Tyne has been undergoing extensions, although completed only four years ago. An agreement was entered into with the Teams Byproducts Co., Ltd., to purchase the surplus gas from a large battery of Otto-Hilgenstock coke ovens about 1½ miles from the Dunston Station. Gas is carried to the station in 16-in. welded steel pipes and is burned under water-tube boilers. The station was originally laid out for four 6000-kw. units, only three of which were installed. The new installation consists of a 12,000-kw. turbo-alternator of the impulse reaction type, built by Richardsons, Westgarth & Co., Ltd., and Brown Boveri—the turbo and alternator, respectively. Merz & McClellan, of Newcastle-upon-Tyne and Westminster, are the consulting engineers.

Decision for Municipal Light Plant

Columbus, Ohio, has a municipal light plant which has been in operation for several years, and in the past few years has been selling some of its day output to private parties. A citizen, James M. Butler, sought from the courts an injunction against the city to prevent this practice, the case being outlined in the Jan. 20, 1914, issue of "Power." Since then the newly elected city solicitor, Henry L. Scarlett, has defended the city.

There were two main contentions made in support of the petition and amendment by plaintiff's counsel: (1) That the City of Columbus, by reason of the sale of current from its electric light plant to private consumers at less than cost is operating its plant at a loss, which loss must be paid by the taxpayers; and (2) that in the sale of such current there is no uniformity or classification of prices among customers. The operation of the plant by the city officials under these conditions was claimed to be such a gross and manifest abuse of their discretionary powers and such a disregard of the rights of the taxpayers as to amount to fraud upon them, entitling plaintiff as a taxpayer to an injunction..

The city solicitor argued in reply that an electric-light plant, such as is owned by the City of Columbus, is operated by the city acting in its proprietary capacity as distinguished from its governmental capacity. Thus the plant would be run as a business concern and, as such, might have profits and might have losses. The sale of electricity for private purposes so far has been incidental, in order to dispose of a portion of the day load, which otherwise was a waste product. The principal use of the plant being for lighting the streets and other public places, it is apparent that when the night load and a very small part of the day load are utilized on city properties the entire operation and maintenance cost, including interest and depreciation on the investment, is a burden upon the public. If the sale of the extra available day load to private consumers pays the extra operating cost incurred by its generation and a proper depreciation and interest charge on the extra equipment necessary for its generation and distribution, and contributes anything, however small, to the fixed charges, then the day load is sold at a benefit to the city and not at a loss.

Municipalities and their officers have the legal power, and it is their duty to apply the surplus power and use of all public utilities under their control for the benefit of their cities and citizens, provided always that such application does not materially impair the use of these facilities for the purpose for which they were primarily created.

As to its rates for private service, the city plant was in competition with a privately owned plant, and had to meet that competition as any business concern would. It did not have enough power to supply the whole city, and therefore furnished electricity to such customers as might use a sufficient quantity, in the judgment of the officers, to net the best returns. The contracts were entered into voluntarily by the private parties, and the rates made were agreed to and were satisfactory. No intimation was raised by the plaintiff that a higher price would have been secured, and so no foundation is laid for charge of fraud. No private consumer had sought court relief on the basis of unequal rates.

Judge Rodgers ruled against the plaintiff and in favor of the defendant, the city, and denied the injunction sought. Some quotations from his ruling are of wide interest, and are as follows:

I am unable to reach the conclusion that the pleadings make a case for injunctive relief, either on the ground of misapplication of corporate funds, or abuse of corporate powers, or the execution or performance of contracts in contravention of the laws governing the city, or through fraudulent or corrupt procurement. The right of the city to furnish electric current to private consumers is conferred by statute wherein it grants the power to establish, maintain and operate municipal lighting, power and heating plants, and to furnish the municipality and the inhabitants thereof with light, power and heat, and to procure everything necessary therefor. And in the exercise of this power the city is exercising an administrative function. It is fundamental that, in the exercise of such duty, courts will not interfere unless the discretion of the officials is so grossly and manifestly abused as to amount to a fraud upon the taxpayers and a disregard of their rights.

Apparently, the theory of plaintiff's counsel is that, whatever service the city renders to one of its private citizens, it must be remunerative at least to an amount equal to the cost of the service. In other words, the service must be self-sustaining; otherwise it cannot be rendered by the city to the individual.

I do not understand that this is the theory upon which the various public utilities of a municipality are operated by it, such as the water-works, lighting and power plants, gas plants, garbage- and refuse-disposal plants, the removal of ashes and other refuse from the residences of its citizens and the like.

The statute granting authority to cities to furnish light and power to its inhabitants does not confer power on the city to sell electric light or power to the inhabitants, but confers power to furnish such light and power. Whether such light and power may be furnished above, at or below cost or even free to the inhabitants, does not appear by the express language of the statute. . . . The city is given power to furnish its citizens electric light and power, and it is left with the city to fix the terms upon which such light and power may be furnished. If the city sees fit to furnish light and power to its inhabitants at less than cost, I see nothing in the statute to prohibit the city, through its officials, from exercising its discretion to that end. If plaintiff's contention were correct, that in the sale of electric current to the inhabitants there must be no loss to the city, and that the sale price must at least equal the entire cost of production, a municipal plant might never be able to furnish its citizens with electric light or power. Of necessity, every municipal plant of this character must start with a few customers; yet as a matter of economy must make preparation in the way of lands, buildings, installation of machinery, wiring, poles, and the like, for probable future increase of business. On the other hand, if the power conferred by the statute upon the city to furnish electric light and power to its inhabitants is construed to mean authority to sell at such prices as the city may determine, the city in the exercise of its proprietary functions is put in a position to operate the plant as business men would engage in a like enterprise. As a matter of economy business men would probably build their plant, not alone to supply present needs, but in anticipation of probable future demands, with the view that the future returns on the investment on account of increasing business would make up for any present losses.

The statutory authority of cities to furnish electric light and power to the inhabitants is found in the general enumeration of powers recited in the statutes, and these powers include the power to maintain police and fire departments, to provide for a supply of water, to establish, maintain and regulate free public band concerts and free public libraries, to provide for the renting of free public hospitals, to provide for the collection and disposal of sewage, garbage, ashes and animal and vegetable refuse, etc. For the use and benefit of its citizens the city charges them for some of the benefits above mentioned which the city has power to furnish, and for others it makes no charge whatever, as for example, the removal of garbage, ashes and refuse matter and the extinguishing of fires.

As it appears to me, so far as the city has the power to and is furnishing a part of its inhabitants electric current, who are willing to pay the price therefor, it is not within the province of the court to interfere with the prices at which the city is disposing of its electric current, merely on the ground that the city thereby is losing money.

A further contention is that the prices charged for the electric current are not uniform under the same or like conditions and are discriminatory among the city's customers. I am inclined to the opinion that the pleadings show a wrong in this respect that is in need of a remedy. That a city through its officials cannot discriminate in furnishing service of any kind to its citizens, but must act impartially in furnishing such service, appears to be fundamental. However, is the plaintiff a proper party to make complaint? The discrimination in rates charged and paid for the electric current

in no wise appears to affect the plaintiff as a taxpayer. In other words, it is not shown that his taxes would be less if there were no discrimination in rates, or in fact would be affected either way; nor does it appear that he has sought to have the city furnish him service at a reasonable rate, and it has been refused, although the city is furnishing like service to others on more favorable terms. In this view of the case I am of the opinion that the plaintiff does not allege sufficient facts in the respect just mentioned to entitle him to injunctive relief.

Rate Publicity Ordered

One of the most far-reaching orders that the upstate Public Service Commission of New York has issued in years went into effect Feb. 15, requiring the rate schedules of all gas and electric corporations and all municipalities subject to the regulation of the commission to be filed in the commission's office, and to be kept in convenient form for the inspection of customers at all offices of such corporations and municipalities where contracts for service are made or payment for services received.

This order follows out the plan of the commission in regulating other corporations under its control, and requiring the fullest publicity of all rate schedules in order to prevent discrimination. The order specifies that the rate schedules are to be uniformly printed and that when asked for by a customer the person having charge of them in the corporation's office shall give all necessary assistance in gaining information therefrom. The schedules include not only rates, present or proposed, but regulations for service and privileges and facilities under each rate.

The Corrosion of Condenser Tubes

We have received from E. Bates, White Bay Power House, Sydney, N. S. W., a copy of a paper on the corrosion of condenser tubes, read by him before the Electrical Association of New South Wales in 1913. In this paper Mr. Bates states that the exceedingly serious corrosion of condenser tubes experienced at the Ultimo power station of the Sydney Tramways had been completely checked by the simple procedure of painting the whole of the interior of the cast-iron water boxes with an anticorrosive paint. Following the success at Ultimo, the same procedure was adopted with equally good results at the power station of the Adelaide Tramways, where much trouble had been experienced from condenser-tube corrosion. Attempts to check this by improving the contact between tubes and tube-plate and by suspending zinc plates in the water boxes had all failed, but on learning of the results achieved by Mr. Bates at Sydney, it was decided to try the same plan at Adelaide. In the first instance, the interior of the water boxes, covers and pipes of one condenser were painted with three coats of biturine solution. The result was that the corrosion did not recommence until the paint was washed off. Subsequently an anticorrosive paint was used, and was found to last three times as long as the biturine solution.

As is well known, many engineers have made claims to success in stopping condenser-tube corrosion, but in many cases an extended trial has proved these pretensions to be illusory. An example brought forward at the discussion on Mr. Bates' paper was one presented at the Ithaca meeting of the American Association for the Advancement of Science in 1906, by W. W. Churchill, who declared that tube corrosion at the Bay Ridge station of the Brooklyn Edison Co. had been traced to stray currents and that the trouble had been completely checked by installing a booster to provide a counter electromotive force. One of the speakers on Mr. Bates' paper related, however, that he had visited New York subsequently and learned that the plan in question had proved a complete failure, and that the booster sets providing the counter electromotive force had been thrown out of service. It is therefore interesting to learn from Mr. Bates that his system is still in use at the Sydney power stations, and with excellent results.

The trouble originally arose with the condensers of certain 5000-kw. turbo-generators. Electrolytic methods of protection were tried on the installation of a new unit, and for eight months this condenser gave no trouble and electrolytic protection was deemed a success. Then, however, the tubes began to fail rapidly. It was therefore decided to try Mr. Bates' plan on two of the older condensers, and when it proved successful with them, the same process was adopted in the case of the new condenser, the electrolytic protection being dispensed with. During the succeeding nine months not a tube failed in this condenser.

Mr. Bates' method is based on the hypothesis that the corrosion, being of the pit-hole type and practically confined to the bottom of the tubes, must be due to the deposit of electro-negative material, and this material must, he concluded, have been derived from the corrosion of the cast-iron water boxes. He states that once a pit hole is started by the deposit of such material, the corrosion will proceed even if the initiating cause be washed away subsequently, since when local corrosion has commenced the "balance" of the alloy is upset. The ordinary condenser tube has, he says, a composition giving a minimum waste by corrosion in normal conditions. If the constitution is altered locally by selective dissolution following the deposit of electro-negative matter, then, even when the latter is removed, the corrosion will continue, owing to the "balance" of the alloy having been disturbed.

During the 15 months which have elapsed since Mr. Bates' paper was read the number of tubes removed from the two older 5000-kw. condensers has, he informs us, not exceeded three per month, while before the Bates method of protection was adopted it was not uncommon to lose 150 tubes from one condenser in a single week.—"Engineering."

Recent Court Decisions

Digested by A. L. H. STREET

Damages Caused By Power Dam—A hydro-electric power company is liable to a suit in a county into which its dam backs water to the injury of inhabitants of that county, although its principal place of business and its plant may be in other counties, according to the decision of the Georgia Supreme Court in the case of Central Georgia Power Co. vs. Stubbs, 80 "Southeastern Reporter" 636. The court decided these further propositions: The Georgia statute, which permits suit to be brought in the county where the cause of action arose, is not unconstitutional. If water is so impounded by the dam as to create a nuisance, to the injury of an adjoining landowner, he may recover damages, including those brought about by sickness of himself and family caused by the nuisance, but, the conditions complained of being permanent, he must recover all of his damages in one suit, not being entitled to prosecute successive actions for continuing injury. The power company is not liable for loss of trade at his mill resulting from people moving away on account of the nuisance.

Insurance of Boilers—A peculiar case involving the liability of a fire-insurance company on an ordinary fire-insurance policy for injury to a stationary boiler was recently passed upon by the Kansas Supreme Court. It appears that at the close of a business day the boiler was left more than half full of water, with the gas which furnished the fuel turned off. The next morning it was found that someone had entered the building and caused the fire to be restarted and kept up long enough after the water was exhausted in steam or by draining to injure the boiler. The next morning the gas was found turned off. On these facts the Supreme Court decided (McGraw vs. Home Insurance Co., 144 "Pacific Reporter," 821) that the evidence was insufficient to warrant the inference that someone not connected with the plant had maliciously caused the injury, so as to render the insurance company liable for the loss. The court holds that proof of the facts stated was not inconsistent with the injury having been caused by someone connected with the plant, in which case the insurance company could not be held on the policy.

Responsibility for Boiler Explosion—In lately affirming judgment against the defendant in the case of Eberts vs. Mount Clemens Sugar Co. (148 "Northwestern Reporter," 810) for injuries sustained by the plaintiff, an employee of the defendant, in a boiler explosion, the Michigan Supreme Court held that an employer's duty to make proper inspection of boilers to promote the safety of employees cannot be discharged by merely entrusting it to a certain employee. In other words, an employer is liable for injury directly attributable to the negligent omission to discover any defective condition of a boiler, although the immediate act of carelessness may have been that of a co-employee of the injured worker to whom the duty of inspection was entrusted. In this case it was the plaintiff's theory that the rear stay-plate of the boiler became bulged or corrugated by overheating, that this was a dangerous condition likely to result in a failure or explosion, and that an inspection, which was negligently omitted, would have disclosed such condition. On the other hand, the defendant claimed that the condition could not have been discovered by a reasonable inspection before the accident and that the initial rupture occurred not in the stay-plate, but in the combustion chamber.

OBITUARY

H. WARD LEONARD

H. Ward Leonard, the well known electrical engineer, died suddenly at the Hotel Astor, New York, on Feb. 18, while attending the annual banquet of the American Institute of Electrical Engineers. He was born in Cincinnati, Feb. 8, 1861, was graduated from the Massachusetts Institute of Technology at the age of 22, and a year later became associated with Mr. Edison in the introduction of the central-station business. After three years in this line he was with the Western Electric Light Co. for a short period, and later became part of the firm of Leonard & Izard. This concern was finally absorbed by the Edison company, and Mr. Leonard became general manager of the combined Edison interests.

In connection with the Ward Leonard Electric Co., which he founded, his later life was identified with a large number of important inventions, among which are the Ward Leonard system of motor control, used generally by the U. S. Navy; the well known multiple-voltage system which bears his name, a lighting system for trains and automobiles, and an electric gear shift, besides other inventions relating to mine hoists, electrically driven reversible rolling mills, locomotives, elevators and gasoline-electric trucks. In 1903 he was awarded the John Scott medal by the Franklin Institute, and also received medals at both the Paris and the St. Louis Expositions. He was a life member of the American Institute of Electrical Engineers. A widow survives him.

ENGINEERING AFFAIRS

The Irish-American Association of Stationary Engineers is the newest organization in this craft. It meets at K. of C. Hall, 81 Hanson Pl., Brooklyn. Harry F. Burns, at the same address, is president.

National District Heating Association—The next annual convention will be held in Chicago, June 1, 2 and 3, 1915, with headquarters at the Hotel Sherman. The papers will be: "Commercial End of the Heating Business," by C. F. Oehlman, of the Denver Gas & Electric Co., Denver, Colo.; "Typical Hot Water Heating Plant," by W. G. Carlton, New York City; "A Pressure Study Survey," by C. C. Wilcox, of Commonwealth Power Co., Jackson, Mich.; "Exhaust Steam vs. Live Steam for Heating," G. W. Martin, New York City; and a paper, the title of which is not yet announced, by E. F. Tweedy, of the New York Edison Co. Reports will be made by the committees on rates, underground construction, public policy, education, meters, station operating and station records. In addition, there will be three addresses by men of national reputation. Altogether, the next convention promises to exceed in attendance and interest any that the association has ever held.

NEW PUBLICATIONS

PRACTICAL IRRIGATION AND PUMPING. By Burton P. Fleming. Published by John Wiley & Sons, New York, 1915. Size 6x9 inches; 260 pages; cloth. Price, $2.

According to the author, the farmer is now looking toward the vast areas on the higher ranges, or mesas, where the latent agricultural possibilities of the soil are enormous. To irrigate this land means the pumping of surface and subsurface water, and it is the purpose of this book to treat chiefly of the subject of pumping. The author considers the matter of wells and well sinking, pumps, pumping machinery, selection of prime movers for pumps, and irrigation by windmill-operated pumps. The chapter on pumping costs should prove interesting to those interested in irrigation. Contractors and engineers, who are called on in their professional capacity to solve the pumping difficulties of irrigation jobs, should find the book of value.

HANDBOOK OF FORMULAS AND TABLES FOR ENGINEERS. By Clarence A. Pierce, instructor in power engineering in Sibley College, Cornell University. With mathematical sections by Walter B. Carver, assistant professor of mathematics, Cornell University. Published by the McGraw-Hill Book Co., New York. Flexible leather; 168 pages; thin paper; tables and diagrams. Price, $1.50.

This book is a compendium of tables and formulas frequently used by students and practicing engineers in making calculations in higher mathematics, mechanics and machine design, and should be found of great convenience to those who may have forgotten or are doubtful of some of the applications of higher mathematics in the solution of enginering problems.

The work is divided into 10 principal sections, covering the subjects of algebra, geometry and trigonometry, analytical geometry, calculus, measurements, physical and chemical properties of substances, mechanics, strength of materials, standard gages, fastenings and flanges, and mathematical tables. It also gives a Mollier entropy chart of the thermal properties of steam. The book affords in convenient form a collection of tables and formulas most commonly used by engineers and for which they have usually been dependent upon reference to a number of handbooks and textbooks.

BUSINESS ITEMS

The Lea-Courtenay Co., 90 West St., New York, due to increased business, has opened its own Chicago branch in the Conway Building, with Mr. Maher, formerly of the Maher & Byrne Co., as manager.

The Whitlock Coil Pipe Co., Hartford, Conn., has just published Bulletin No. 22, Series No. 3, dealing with the subject of heating surfaces in steam actuated water heaters. Copies are mailed on request.

The Schaeffer & Budenberg Mfg. Co., in order to take care of its increasing business, has moved its offices and plant to the splendid new building at South Fifth and Berry St., Williamsburg, Brooklyn, N. Y.

"Central Power Station Economy" is the title of a very interesting booklet published by the Wm. B. Scaife & Sons Co., Pittsburgh, Penn. It is a treatise on water purification for all purposes. Copies are mailed for the asking.

The Combustion Engineering Corporation, 11 Broadway, New York, has just issued a new booklet descriptive of the type "E" stoker. It is a 20-page booklet, well illustrated, giving a complete description of the stoker, construction and operation and showing several installations. Copies are mailed on request.

William B. Merrill & Co., 3368 Washington St., Boston, Mass., has received order to furnish "Tripp" metallic packing for all piston rods and valve stems of the new steamer now being built for the New York & Porto Rico Steamship Line. The company has also received during the past month orders for 234 sets of "Tripp" metallic packing from Ingersoll-Rand Co.

CONTRACTS TO BE LET

Bids received until Mar. 12, 1915.

Five Pumping Engines

MAYFAIR PUMPING STATION.
Department of Public Works.
Chicago, February 17, 1915.

Sealed Proposals will be received by the City of Chicago until 11 A.M. Friday, March 12th, 1915, at Room 406 City Hall, and then publicly opened, for furnishing and erecting five pumping engines at the Mayfair pumping station, Chicago, as follows:

Three pumping engines, capacity 25 million gallons per day, normal head 140 ft.

Two pumping engines, capacity 17½ million gallons per day, normal head 200 ft.

The contract includes discharge piping and suction connections for seven engines, according to Plans and Specifications on file in the office of the Department of Public Works of said City, Room 406 City Hall.

Proposals must be made out upon blanks furnished at said office, and be addressed to said Department, indorsed "Proposals for Five Pumping Engines, Mayfair Pumping Station," and be accompanied with Twenty-five Thousand Dollars in money or a certified check for the same amount on some responsible Bank located and doing business in the the City of Chicago and made payable to the order of the Commissioner of Public Works.

The Commissioner of Public Works reserves the right to reject any or all bids.

A deposit of three hundred dollars ($300.00) will be required to insure return of plans and specifications.

No proposal will be considered unless the party offering it shall furnish evidence satisfactory to the Commissioner of Public Works of his ability, and that he has the necessary facilities together with sufficient pecuniary resources to fulfill the conditions of the Contract and Specifications, provided such Contract should be awarded to him.

Companies or firms bidding will give the individual names as well as the name of the firm with their address.

L. E. McGANN,
Commissioner of Public Works.